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COMMUNICATIONS LABORATORY

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE ■ UNIVERSITY OF ILLINOIS AT CHICAGO

PREPARATIONS OF PROCEEDINGS MANUSCRIPT FOR
NATO-ARW-DIMRP'86

FINAL REPORT

WOLFGANG-MARTIN BOERNER

ARO-GS/P-26773:DAAL-03-89-K-0075

1991 AUGUST 31

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Wolfgang-M. Boerner, Professor & Director

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THE COMMUNICATIONS AND SENSING LABORATORY
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Director & Senior Professor: Dr. Wolfgang-Martin Boerner

FACILITY DESCRIPTION

A center of research excellence in ultra-wideband electromagnetic, acoustic and acousto-elastic sensing & imaging has been set up with the support from various research offices within the U.S. Departments of Defense, Energy and Transport dealing with high resolution wideband polarimetric radar imaging, remote sensing, radar/sonar, and seismic image interpretation at an annual funding level exceeding $400,000.00 (operating) for the past eight years.

Novel electromagnetic vector inverse scattering theories and signal/image processing techniques are derived which make use of complete polarization scattering matrix information of the co/ cross-polarized radar cross sections, and can be implemented in the development of radar target vs. clutter detection, discrimination, classification, imaging, and identification algorithms. The major applications of this high resolution wideband polarimetric radar research are related to military and civil radar for target in clutter handling, military and civil remote sensing of the environment, the detection of mines on land and in coastal surf-zones, the advancement of air-borne weather radar, as well as advanced surveillance and tactical radar systems including the design of advanced polarimetric synthetic aperture radar systems for terrestrial and space surveillance. Considerable research expertise is developed in advancing novel high-speed parallel processing data-intense image computer analysis for extending standard scalar (acoustic/radiographic) projection tomographic (CAT-Scan) methods to vector diffraction tomographic imaging for electromagnetic vector wave interrogation with material media whose index of refraction is changing abruptly including image applications in medicine (kidney/lung/brain), detection of buried objects (broken sewerage pipes, mine-countermine), and propagation through inhomogeneous media (hydrometeoric/electric storm, coastal surf-zone environments, and ocean marine boundary layer).

In addition, extensive ELF/VLF (extremely/very low frequency) electromagnetic and acoustic natural man-made radiation noise analyses are being carried out which include the assessment of detrimental after-affects of industrial and electric power transmission systems radiation on the environment, the ionosphere and the magnetosphere. In this context, recently new international research in seismo-electromagnetology was initiated on advancing signal processing techniques for detecting and telemetering electromagnetic/acoustic/seismic earth/sea-quake precursor radiation in order for early (in advance) prediction of earth/sea-quakes.

The laboratory possesses its own DEC VAX-11/750 research computers with computer vector/color graphics & parallel processing and display systems, as well as other specialized analog/digital conversion and image acquisition hardware, signal analyzers and various functional radar mode simulators (total purchase value above $600,000.00). Experimental radar data are obtained from other collaborating research centers within DoD, DoE, DoT, NASA, USGS and NIH, the national electronics industry (Boeing, General, Dynamics, Martin-Marietta, Teledyne-Micronetics/-Global), and NATO (SHAPE-TC, THORN-EMI, AEG, SEL-ITT, SIEMENS-MED, DFVLR-OPH, ONERA, NTNF-PFM, etc.). Currently, no in-house experimental research is conducted but rather close collaboration with International Research Development & Engineering Centers involved in wide area surveillance of the terrestrial and planetary atmospheres and crusts, for the purpose of obtaining such data sets is actively pursued.

PREPARATION OF PROCEEDINGS MANUSCRIPT
FOR NATO-ARW-DIMRP'88:

'DIRECT AND IVERSE METHODS IN RADAR POLARIMETRY'
BAD WINDSHEIM, FRG, 1988 SEPT 18 - 24.

FINAL REPORT

Wolfgang-Martin Boerner

(1991 August 30)

U.S. ARMY RESEARCH OFFICE
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13. ABSTRACT (Maximum 200 words) This publications' contract is for support toward producing the **FINAL MANUSCRIPT** of the Proceedings of a **NATO Advanced Research Workshop** on **'Direct and Inverse Methods in Radar Polarimetry:** This is the second ARW in a series of three NATO-ARW's dealing with direct and inverse methods in electromagnetic sensing, imaging and target identification versus clutter discrimination with applications to electromagnetic wideband, wide area surveillance of the terrestrial and planetary deep-earth, surface to atmospheric environments. During the first **NATO-ARW-IMEI'88** (NATO-ASI, Series C-143, 1985), we assessed the inverse methods in electromagnetic imaging primarily for solving radar scattering problems, including mathematical and numerical inversion techniques and signal and image processing with specific emphasis on the vector (polarization) nature of electromagnetic fields. The resulting two-part Proceedings are highly praised in the international literature resulting in an extraordinarily high sales record which encouraged us to plan, to organize and execute this second ARW on the more specific topic of "Direct and Inverse Methods in Radar Polarimetry": **NATO-ARW-DIMRP'88** (NATO-ASI, Series C-350, Parts 1&2, 1991) emphasizing advancements made in polarimetric radar (POL-RAD) and in polarimetric synthetic-aperture radar (POL-SAR) theory, metrology, signal/image processing, and polarimetric technology.

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JEAN RICHARD HUYNEN

IN DEDICATION TO

SENIOR RADAR POLARIMETRIST: JEAN RICHARD HUYNEN
(*1920 October 8, Batavia, Nederlands Oost Indie)

Among the engineering scientists who have most decisively contributed toward forefront advances for

"The Development of Polarimetric Radar Techniques and Radar Target Phenomenology which have Advanced Theory, Metrology, and Applications of Radar Target Detection, Classification and Identification,"

Dr. J. Richard Huynen stands out, next to the late Professor Edward M. Kennaugh, as one of the towering pioneers.

Rick developed the Phenomenological Theory of Radar Targets in the course of his long professional life during the years of about 1949 to 1977, based on the earlier work of Sinclair, Rumsey, Deschamps, Gent, Graves, and Copeland, which culminated in his D.Sc. dissertation delivered at the Delft University of Technology under the promotion of famed Professor Dr. Ir. Johannes P. Schouten on 1970 December 16. By mere coincidence, Ir. André J. Poelman sat in on Rick's defense and, without delay, immediately thereafter went about and built the first truly dual polarization coherent radar system, culminating in the design of the first high power rapid electronic polarization switch, in order to verify Rick's visionary concepts of the target characteristic equations expressed in terms of his **Polarization Fork.** In the meantime, this monograph has been studied world-wide; and so have many of his subsequent treatises been discussed and assessed most critically, in the West and the East alike, and those have become the fruit of thought and inspiration for many pioneering advancements in polarimetric radar technology such as those by André J. Poelman, Vladimir A. Potekhin, Jerry L. Eaves, Anatolij Ivanovich Kozlov, Donald J.R. Stock, and many others.

In particular, with the recent resurgence of polarimetric radar device technology his basic work was immediately in demand and has become instrumental in advancing polarimetric radar theory, metrology, signal/image processing, and technology from every possible angle of approach as is also documented in these Proceedings. Although not all his visionary concepts are accepted today, it is with great pleasure to have him still contribute to the field so actively and it is also with the sincerest gratitude from all of us to him for his congenial invigorating stimulations and continued strive for advancing radar polarimetry that we are dedicating these Proceedings of the NATO-ARW on Direct and Inverse Methods in Radar Polarimetry (1988) to him.

On 1990 December 23, Rick suffered an aneurysm and had to undergo a nine-hour craniotomy, from which he recovered rather well. We wish him well and we hope we all continue to enjoy our interactions with this vivid and witty nature for a long time to come.

On behalf of all participants,

Wolfgang-M. Boerner
University of Illinois Senior Scholar

1. FOREWARD WITH ACKNOWLEDGEMENTS

This proceedings publications project deals with the preparation of the manuscript for the PROCEEDINGS of the second NATO Advanced Research Workshop (ARW) in a series of three NATO-ARW's concerned with the advancement of **"DIRECT AND INVERSE METHODS IN ELECTROMAGNETIC SENSING AND IMAGING"**, planned, coordinated and executed by the author in collaboration with his international team of NATO research experts in high resolution electromagnetic sensing and imaging in wide area surveillance of the terrestrial (and plaentary) surface layer(s).

Whereas the first workshop in this series, **NATO-ARW-IMEI'83** (NATO-ASI, Series C, Vol. 143, Pts. 1 & 2, D. Reidel Publishing Co., Dordrecht, NL, 1985) dealt with, **'INVERSE METHODS IN ELECTROMAGNETIC IMAGING'**, the second workshop, NATO-ARW-DIMRP'88 (NATO-ASI, Series C, Vol 350, Pts 1 & 2, D. Reidel Publishing Co/Kluwer Academic Publishers, Dordrecht, NL, 1991) deals with **'DIRECT AND INVERSE METHODS IN RADAR POLARIMETRY'**. As a result of the very positive and enthusiastic response of the true majority of participants and the post-workshop contributors (eminent radar polarimetrists from the Eastern Block), we are now in the preparatory phase of planning for the third workshop, **NATO-ARW-WPDR'93**, which will take place, again with a five year delay, at the same congress center in Central Europe at the KUR-UND-KONGRESS-HOTEL RESIDENZ, BAD WINDSHEIM, CENTRAL FRANCONIA, FRG during 1993 SEPT 19 - 25 dealing with **'direct and inverse problems'** in **'WIDEBAND POLARIMETRIC DOPPLER RADAR SENSING AND IMAGING'** for the **'instantaneous detection, ranging, imaging and identification of hostile targets endangering and hazardous agents polluting our global planetary environment'**.

The first two workshops were attended each by about eighty active workshop participants plus about forty scientific observers and twenty accompanients, and a similar number of participants is expected for the third workshop in 1993. The participants at the first workshop (1983) were mostly recruited from NATO-member and allied Scandinavian, other Western European and from Austral-Asian countries which was slightly expanded for the second workshop to also include contributors from the NW Pacific RIM and a few Eastern Europeans. In keeping pace with the mind-boggling changes due to the waning of the Cold War period, throughout the past five years since President Mikhail Gorbachev steered the political wheel of the USSR in a more 'westerly direction', we invited special state-of-the-art post-workshop contributions by several renowned Soviet pioneers in radar polarimetry. The re-translation and major re-editing of those important post-workshop contributions were the main cause for delaying the submission date of the FINAL MANUSCRIPT of the Proceedings for the second workshop 'NATO-ARW-DIMRP'88' to Kluwer Academic Publishers at **DORDRECHT, THE NETHERLANDS.** Because of the dramatic changes in reshaping the former 'USSR' as well as in the re-alignment of world powers as a result of the East-West rapproachment, a rather representative number of experts in **'wideband electromagnetic sensing and imaging for wide area terrestrial and planetary environmental surveillance'** will be invited from the former **'Eastern Block'** to contribute most actively to the programme and resulting proceedings of **'NATO-ARW-WPDR'93'** as is envisioned in the concluding preview contribution **IX-08** of these PROCEEDINGS OF NATO-ARW-DIMRP'88 (NATO-ASI, Series C, Mathematical and Physical Sciences, Vol. C-350, Pts. 1 & 2, Kluwer Acad. Publ/Dordrecht, NL, 1991).

In concluding the foreward, we would like to take this opportunity for expressing our sincerest gratitude on behalf of all participants for the financial, mental and technical support provided with much enthusiasm but also wisdom by Dr. Walter A.

Flood, the Director of the **US ARMY OFFICE OF RESEARCH, GEOSCIENCES PROGRAMME,** to **Mr. Lloyd W. Root**, formerly with the **US ARMY MISSILE LABORATORY, HUNTSVILLE, AL** and to **Dr. Daniel Cress**, Senior Radar Scientist, formerly with the **Environmental Laboratories, THE US ARMY CORPS OF ENGIEERS, WATERWAYS EXPERIMENT STATION, VICKSBURG, MS.** Also, we wish to recall here that just prior to **'NATO-ARW-DIMRP'88'**, **BAD WINDSHEIM, FRG, 1988 SEPT 18 - 24**, another closely related event, the **POLARIMETRIC TECHNOLOGY WORKSHOP, Redstone Arsenal, AL, 1988 August 16 - 18**, was so well organized and executed by Mrs. Brenda L. Matkins/MI-COM, Mr. Lloyd W. Root and Dr. Robert J. Heaston/GACIAC which then culminated in the truly stimulating scientific meeting at Bad Windsheim, FRG, precisely during the NATO Reforger Exercises, as summarized in the **Director's Foreward of NATO-ARW-DIMRP'88** and its concluding preview **(IX-08)** of NATO-ARW-WPRD'93.

Finally, we would also like to add our sincere gratitude to the scientific director (s) and pertinent research scientists of the **US ARMY MATERIAL COMMAND, US ARMY RESEARCH, DEVELOPMENT AND STANDARDIZATION GROUP (UK), Edison House, London, UK,** and in particular to Dr. John M. Zavada and Dr. Karl H. Steinbach for their continual support of this project.

The planning, organizing and execution of this series of three related NATO-ARW's was made possible by the contructive and congenial advice of Dr. Tilo and Mrs. Barbara Kester, NATO Publications Coordination Office and especially by the NATO-ARW/ASI Programme Directors including Dr. Tilo Kester and especially the late Dr. Mario di Lullo (*DOMODOSSOLA, PIEPMONT, IT: 1925, December 14, $^{+}$BRUXELLES, BE: 1986 June 24), by his successor Dr. Craig Sinclair, and their successors Dr. Paul Rambaut, Dr. Giovanni A. Venturi and Dr. Luigi Sertorio. Their inspiration and continual encouragement especially during the rather drawn out editing of the manuscripts of their Proceedings is especially appreciated.

Similarly, we wish to extend our sincerest thanks to the publishers of these proceedings, Mrs. Nel Pols van der Heijden and to Mrs. Nel de Boer of Kluwer Academic Publishers, Dordrecht, NL, as well as to the editorial staff of UIC-EECS/ CSL, and in par icular to Ms. Mirian R. Mailey and Mr. Richard W. Foster for their diligent editing contributions, and to Yan, Wei-Ling, Xi,An-Qing, Liu, Chuang-Li and Zhang, Xin for proofreading the final manuscript.

Finally, a very special and highly deserved note of thanks is extended to the director, Dr. Wolfgang Keydel, of the Institute of Radio Frequency Technology and Remote Sensing of the German Aerospace Research and Test Facility DLR-Oberpfaffenhofen and his able research and support staff, and especially of Mr. Reiner Weppner, the institute manager, for their constructive assistance and effective support throughout the entire extent of this project.

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4. TECHNICAL REPORT ON PUBLICATIONS OF PROCEEDINGS

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4.0 Overview: This is the second ARW in a series of three NATO-ARW's dealing with direct and inverse methods in electromagnetic sensing, imaging and target identification versus clutter discrimination with applications to electromagnetic wideband, wide area surveillance of the terrestrial and planetary deep-earth, surface to atmospheric environments. During the first **NATO-ARW-IMEI'88** (NATO-ASI, Series C-143, 1985), we assessed the inverse methods in electromagnetic imaging primarily for solving radar scattering problems, including mathematical and numerical inversion techniques and signal and image processing with specific emphasis on the vector (polarization) nature of electromagnetic fields. The resulting two-part Proceedings are highly praised in the international literature resulting in an extraordinarily high sales record which encouraged us to plan, to organize and execute this second ARW on the more specific topic of "Direct and Inverse Methods in Radar Polarimetry": **NATO-ARW-DIMRP'88** (NATO-ASI, Series C-350, Parts 1 & 2, 1991) emphasizing advancements made in polarimetric radar (POL-RAD) and in polarimetric synthetic-aperture radar (POL-SAR) theory, metrology, signal/image processing, and polarimetric technology.

Direct and inverse scattering/diffraction methods have become fundamental tools in physical sciences for remotely sensing and 'deep-sounding' unknown objects and underburden for reconstructing their physical properties. Significant technologic advances during the last few years in the field of electromagnetic probing, especially in the m-to-sub-mm wave, infrared, optical and ultraviolet region, as well as of data processing and mathematical inversion methods opened up new avenues with regard to detection, imaging and identification of natural and cultural (created by man or other living beings) objects and gaseous agents in our environment. Information previously considered irretrievable can now be recovered from noise and clutter disturbed data by use of more advanced electromagnetic sensing, sounding and imaging techniques incorporating inversion methods, neural networking, spread-spectrum noise mitigation procedures, etc. In particular, polarimetric technology in most spectral regions enjoyed rather rapid advances during the 1980's, and from the outset of discussing the preparation and execution of this workshop and the editing of its resulting Proceedings **NATO-ARW-DIMRP'88 (NATO-ASI, Series C-350, 1991)**, we wish to emphasize that **by incorporating COHERENT POLARIMETRIC PHASE INFORMATION into radar signal and image processing, one can anticipate, and one is already witnessing in POL-SAR image analysis, a breakthrough which is at least comparable to that brought about by the advent of holography and computer-assisted tomography (CAT-SCAN) and its applications to improving Synthetic-Aperture Radar(SAR) and REAL/INVERSE-Synthetic-Aperture-Radar**

(RAR/SAR).

Although considerable Research & Development & Engineering (R&D&E) efforts have already been expended during the past three decades, there still exist many "grey areas" in theory, methodolgy, calibration, signal/image data formatting/processing and in technology of radar polarimetry (POL-RAD, POL-SAR, POL-RAR, POL-ISAR) which we attempt to illumiate during the prospective second ARW covering primarily the meter-to-submillimeter wavelength, infrared and also the optical regions of the electromagnetic spectrum, whereas in a third ARW **(NATO-ARW-WPDR'93)** the entire non-radioactive spectal regions will be considered in the advancement of **'Wideband Doppler Polarimetric Radar Sensing and Imaging in Wide Area Electromagnetic Surveillance of the Terrestrial and Planetary Environment,'** with specific application to the **'Instantaneous Detection, Ranging, Specification and Identification of Hostile Targets Endangering and Hazardous (solid/liquid gaseous) Agents Polluting its Biosphere.'**

In this second ARW major emphasis is placed on the basic principles of electromagnetic wave interrogation with natural and/or 'cultural (man-made or created by other beings)' media and objects, the optimal structuring of illumination and detection, optimal recovery of useful target signals, mathematical and data processing methods and representative applications mainly focused on the advancement of polarimetric radar theory, metrology, system calibration, data processing and technology. Because insufficient time was available during the first and second ARW's, during various recently convened polarimetric expert meetings of renowned radar polarimetrists from the East (mainly Poland, Bulgary, Czechoslovakia and the Soviet Union) and the West (selected participants of the first two NATO-ARW's), attention was paid to vector signal processing in consideration of more recent post-workshop developments in advanced polarimetric radar detection and estimation theory of the complete polarimetric vector wave information that can be made available by novel **HI-TECH Complete Polarimetric (Coherent Phase Scattering Matrix) Radars** which resulted in an additional twenty post-workshop contributions including ten from Eastern polarimetric radar experts.

Both **NATO-ARW-IMEI'83** and **NATO-ARW-DIMRP'88** generated lively international interaction among previous workshop participants which expanded greatly, resulting in **several national Polarimetric Radar Workshops and Symposiums in the USA, UK, FRG, ITALIA, FRANCE, POLAND, AUSTRALIA, JAPAN and the 'USSR', with express request of staging the third NATO- ARW-WPDR'93 again at the Kur-und-Kongress-Hotel Residenz, Bad Windsheim, Central Franconia, FRG during 1993 SEPT 19 - 25.** Especially, in consideration of the truly dramatic changes in world politics, the re-alignment of world powers, the changing defense strategies and the emerging global environmental planetary crisis, a third workshop was enthusiastically advocated by the international polarimetric radar community and is to deal with the advancement of "High Resolution Electromagnetic Instantaneous Detection, Sensing, Specification, Imaging and Identification" of "Global Environmental Planetary Defense Threats." In this important novel discipline of "Global Environmental Planetary Surveillance", we need to explore the specific "instantaneous disaster - prevention and utilization capabilities of the entire electromagnetic spectal regions" which is the main theme of our third workshop.

4-A. WORKSHOP DESCRIPTION: NATO-ARW-DIMRP'88: Kuk-Hotel-Residenz, Bad Windsheim, FRG:1988:SEPT 18 - 24.

A.1 OBJECTIVE OF NATO-ARW-DIMRP'88:

In-depth assessment of the state of the art of direct and inverse methods of high resolution radar polarimetry used in radar target versus clutter separation, target/clutter classificaton, target/clutter imaging, vector diffraction tomography, polarimetric remote sensing and radar meteorology. Creation of stimulating interactions using keynote reviews, succint papers, poster sessions, and extensive working group discussions in order to produce a solid set of Workshop Proceedings with recommendations for near-future research investigation.

A.2 HISTORICAL OUTLINE:

A second NATO-ARW in the field of electromagnetic imgaing, radar remote sensing, and target versus clutter discrimination has taken place recently and was planned, organized, and hosted by Dr. Wolfgang Keydel of the German Aerospace Research and Test Facility (DFVLR) in Oberpfaffenhofen, FRG; and Prof. Dr.-Ing. Hans Brand, Director, University of Erlangen-Nürnberg, HF-Institute, FRG; together with Prof. Wolfgang-M. Boerner, University of Illinois at Chicago, USA. About ninety experts from eighteen countries, including NATO Europe, USA, Canada, and Japan interacted for seven days in the quaint spa of Bad Winsheim, close but remote from the tourist center of Rothenburg and Nürnberg of Central Franconia. Whereas during the first NATO-ARW-IMEI'83, we assessed the inverse methods in electromagnetic imaging primarily for solving radar scattering problems, including mathematical and numerical inversion methods, during this second NATO-ARW-DIMRP'88, we concentrated on direct and inverse methods exclusively related to radar polarimetry (including *every single* presentation of about 72).

High resolution radar polarimetry has most recently become an indispensible tool in modern electromagnetic sensor technology, both in the civil and military sectors, as well as in remote sensing and radar meteorology and oceanography. From the outset, we wish to emphasize that by incorporating coherent polarimetric phase information into radar signal and image processing, one can anticipate a breakthrough which is at least comparable to that brought about by the advent of holography and computer assisted tomography and its applications to Synthetic Aperture Radar (SAR) and Inverse Synthetic Aperture Radar (ISAR). Although considerable R&D efforts have already been expanded during the past three decades, there still exist many "grey areas" in both theory and techniques of radar polarimetry which we wish to illuminate during the prospective ARW covering the meter-to-sub-millimeter wavelength, infrared, and also optical regions of the electromagnetic spectrum.

A.3 BACKGROUND:

In an effort to clear up some of the still remaining misconceptions and in order to advance this very active discipline of high resolution polarimetric radar imaging and remote sensing, our ARW-DIMRP'88 is opened with a **Historical Session (O)**, including the keynote presentation on **"Polarization in Nature"** by Dr. Günter P. Können, leading to two **basic sub-sessions (I and II)** during which the current state of the art is assessed, which includes proper foralism of polarization states, matrices, and its transformations, followed by **session III** on Basic Polarimetric Metrology

and Systems Calibration and culminating in a **sub-session (IV)** on polarimetric radar target/ clutter concepts and phenomenology. In addition, another four basic sub-sessions have been included on polarimetric radar device technology **(V)**, signal processing **(VI)**, vector (polarization) diffraction tomography **(VII)**, and the polarimetric "sub-surface" imaging of concealed objects **(VIII)**. The Workshop terminated in five applied sub-sessions, including polarimetric technology **(IX)**, polarimetric multispectral/static imaging **(X)**, polarimetric SAR/ISAR imaging **(XI)**, polarimetric remote sensing **(XII)**, polarimetric radar meteorology **(XIII)** and polarimetric oceanography **(XIV)**. Each of these fourteen sessions is initiated with one or two major state of the art reviews by renowned experts. Additional critical assessment papers are presented with the objective of addressing problems to be resolved during working discussion group activities. Six working group discussion group topics have been chosen, addressing the most urgent problems which need to be resolved in order to guarantee unhampered continual progress in theory and technique of mm-to-sub-mm wavelengths, IR, optical, radar, and lidar polarimetry. The topics included a critical assessment of polarimetric literature **(W-A)**; polarimetric target and clutter analysis **(W-B)**; polarization diffraction tomography **(W-C)**; unification of nomenclature, standards, and conventions **(W-D)**; calibration, formatting, and processing of POL-RAD/SAR /ISAR measurement data **(W-E)**; and the acceleration of international (NATO) interaction **(W-F)**. The workshop discussion group summaries were presented and discussed during the Final Session **(XV)**. All participants were invited to witness the progress made at the Carl Zeiss R&D Electronics Center, Oberkochen, IR/Optical Imaging Division, as well as at the AEG, Radio & Radar Systems, R-D-M Center, Ulm, Polarimetric mm-Wave Technology Division. Finally, the workshop was concluded with an introduction to the currently most advanced polarimetric C-band doppler radar system at the DFVLR-Oberpfaffenhofen, Advanced Radar Meteorology Instrumentation Facility, which was viewed and its multi-mode operational capabilities presented during a post-workshop field trip to Oberpfaffenhofen together with all participants as the final and last event of this Workshop, before the participants were formerly discharged at the Munich Central Railroad Station on 1988 SEPT 24, 18:30.

A.4 Lecture Session & Workshop Discussion Group Outlines

A.4.1 Lecture Outlines

1.0 Opening Session

Review of pertinent direct & inverse scattering methods used in Radar Polarimetry (Wolfgang-M. Boerner). Keynote address on "Polarization in Nature" by Dr. Günter P. Können. State-Of-The-Art-Reviews in Basic and Applied Radar Polarimetry (post-workshop contributions).

1.1 Basic Polarization Theory

Although the polarization properties of electromagnetic waves are well understood, there still exist many unresolved questions both in theory and application of radar polarimetry which will be addressed for both the coherent and partially coherent wave treatments.

1.2 Polarimetric Scattering Theory

Pertinent analyses of geometric and physical optics inverse scattering theories and their relevance to polarimetric radar target phenomenology

are still ongoing, and in this Section specific emphasis is placed on the extension of the Kennaugh-Cosgriff transient ramp response methods to the slightly bistatic and completely polarimetric cases.

1.3 Polarimetric Radar Metrology

The design of the optimum polarimetric radar system still requires resolution of several questions pertaining to basic polarimetric radar metrology, including proper standardization of measurement procedures for scattering matrix measurements, polarization state transformations, dual polarization antenna measurements, etc. Also, the questions of designing the most suitable set of calibration targets as well as defining proper pre/in/post-flight calibration methods are not resolved.

1.4 Polarimetric Signal/Image Processing

Provided that the scattering matrix is known on a POL-RAD bin-by-bin, POL-SAR pixel-by-pixel basis, entirely novel signal and image processing methods are feasible and have recently been deviced.

1.5 Vector (Polarization) Diffraction Tomography

Imaging in inhomogeneous media requires the generalization of straight-line projection tomography to diffraction tomography by staisfying at least the Rytov-Born approximations. In case the true depolarizing terms $(\nabla\varepsilon/\varepsilon)$ and/or $(\nabla\sigma/\sigma)$ can no longer be neglected in the wave equation, a further extension to vector diffraction tomography is required. Applications to the detection and imaging of concealed objects in strongly inhomogeneous media will be discussed.

1.6 Polarimetric Radar Device Technology

In order to deploy polarimetric radar systems in practice, one requires polarimetric channel isolation of about 35dB, sidelobe reduction of about 30 dB or better, etc. In addition, we require that the polarimetric antenna state switching is reciprocal and the radiation patterns are polarization state isotropic. Recent advances on how to achieve these and similar goals will be discussed.

1.7 Polarimetric SAR/ISAR

Most recently, polarimetric synthetic aperture radar systems and their inverse configurations have become available and thus allow one to deploy the novel concept of the Polarimetric Matched Image Filter which is based on purely polarimetric (scattering matrix) optimization procedures. The rapid development of these intriguing new target enhancement versus background clutter rejection methods will be discussed and verified with the use of recently available POL-SAR data sets.

1.8 Polarimetric Radar Meteorology and Oceanography

Polarimetric radar systems implementation is especially well suited for the analysis of meteorologic and oceanographic scatter for which the term $(\nabla\varepsilon/\varepsilon)$ shows marked local changes. Recent existing advances in this field will be discussed.

A.4.2 Workshop Discussion Group Outlines

2.1 Workshop Discussion Groups

The workshop discussion group activities are intended to provide recommendation for potential research projects. The six topics chosen define issues for which immediate answers are required. Details on the Working

Discussion Group Topics and Activities were provided with the final announcement and here, we refer to the Technical Program Outline (p.TPO-4), for the listing of the six specific self-explanatory group topics.

A.5 Programme

The program was executed precisely according to the outlines provided in the Final Technical Program Outlines, which are attached. In addition to the scientific workshop program, one daily cultural event was included and an active spouses scientific/cultural tour program was also maintained as outlined in the attachments.

Attachments: Final Programme Outlines

7.1 Final Technical Program Outline

7.2.1 Final Information on Arrangements for NATO-ARW-DIMRP'88, Sept 18-24

7.2.2 Final Information for Working Group Program

7.2.3 Spouses and Cultural Program

4.B SUMMARY OF MOST IMPORTANT EVENTS

In this section we report on the day-by-day activities during the workshop highlighting the most important events and pertinent results. Various contributions by hosts and senior participants are here assembled together with excerpts of the Proceedings Foreward by the Workshop Director and the Chief Editor of the Proceedings of NATO-ARW-DIMRP'88 (NATO-ASI, Series C-350, Pts. 1 & 2, D. Reidel, Dordrecht, NL, 1991).

B.1 Address of the Host Nation

(by Wolfgang Keydel, Director, Institute of Radio Frequency Technology, German Space and Aerospace Research Establishment DLR-OBERPFAFFENHOFEN, FR (West) Germany)

Besides amplitude, frequency and phase, the knowledge of the polarization behavior is essential for the understanding of the scattering mechanism and the interaction between electromagnetic waves and respective targets. The need of polarization information utilization for military and civilian reconnaissance and remote sensing is steadily increasing. However, the total information content of 'polarization' is, up to now, not known exactly and the respective methods and techniques for polarization measurement, polarimetric systems calibration, data evaluation and data interpretation are in many aspects not yet sufficiently developed.

Therefore, this workshop on direct and inverse methods in radar polarimetry has been facilitated in order to assess and promote the state of the art of high-resolution radar polarimetry. Especially, the use of polarimetry for target-clutter separation and target- and clutter-classification and imaging as well should be main topics for workshop deliberations. For this purpose, more than 100 experts came together in Bad Windsheim concentrating on direct and inverse methods exclusively related to radar polarimetry which has recently become an indispensible tool in modern electromagnetic sensor technology in the civil and military sectors as well and in the different fields of deep earth sounding, space remote sensing, and radar meteorology.

If so many experts which represent the key persons in this important scientific field from countries of the eastern and western world meet for a workshop, then the scientific community will expect relevant results. Those results have been brought together in these proceedings. A more general text and source book on this subject matter does not exist. It seems an impossible task for one man to write a suitable book because of the great variety of subjects and the wide range of applications; even if a single expert or a group had to produce a book, it would certainly have removed them from active research for several years. Therefore, in preparing the proceedings of this workshop, several review papers have been introduced, which together with more specific papers, should provide a good overview on the subject matter. Thus, may the resulting proceedings serve as a source and reference book where none existed before.

At this place, I want to express my gratitude to Professor Wolfgang-M. Boerner. He was the conceiver, the organizer and the promoter of this workshop. He solicited the necessary funds, his enthusiasm encouraged leading scientists to participate and to contribute to the workshop and to these proceedings; he established the program, organized the sessions and selected the cultural program, and edited this textbook. Wolfgang-M. Boerner was one of the first who realized the importance of polarimetry

for reconnaissance and remote sensing and he always acted as a forerunner in this field. Therefore, he was the driver and the motor, all in one, of this workshop. We all owe him the debt of gratitude.

B.2 OPENING REMARKS

(by Jerry L. Eaves, Associate Director, Radar and Instrumentation Laboratory, Georgia Tech. Research Institute, Georgia Institute of Technology, Atlanta, GA USA)

It was my honor and pleasure to attend the Inverse Methods in Electromagnetic Imaging (IMEI) NATO Advanced Research Workshop in 1983 and the Direct and Inverse Methods in Radar Polarimetry (DIMRP) NATO Advanced Research Workshop in 1988. Both workshops were held in late September at the Kur-und Kongresshotel Residenz which is adjacent to the Kurpark in Bad Windsheim, FRG.

After attending the NATO-ARW-IMEI in 1983, it was my opinion that the workshop was one of the best organized and most enlightening technical meetings I had attended in many years. In retrospect, I must say that the 1988 NATO-ARW-DIMRP may have been an even greater success. The director, Dr. Wolfgang-M. Boerner, assembled more than 100 renowned scientists and engineers from 14 different countries including China and Poland. All were active participants in the workshop as speaker, session chairman, working group chairman/member/ reporter, moderator or critical observer.

The primary objective of the 1988 NATO-ARW-DIMRP was to provide a forum for free and efficient interchange of radar polarimetric theory, techniques, applications and research on an international basis. The objective was met through the presentation of some 72 technical papers by polarimetry experts from countries in Europe, North America and Asia.

The Director and his Codirectors facilitated the international interaction and technical exchange by organizing the workshop participants into six working groups. Each working group was assigned to address a specific unresolved issue relating to radar polarimetry and to provide recommendations for potential future research projects which will require active interactions among engineering scientists of all NATO-member countries. The Reporter for each working group presented a ten-minute summary of his group's activities, conclusions and recommendations. The final reports are included in these Proceedings of the NATO-ARW-DIMRP'88.

After inspection of the headings and the dedication address you will observe that our workshop has been dedicated to one of the pioneering radar polarimetrists, Dr. J. Richard Huynen, who so strongly advanced theory and concepts next to Prof. Edward Morton Kennaugh to whom the first workshop was dedicated. It gives me special pleasure to congratulate Rick on behalf of all participants of this NATO Advanced Research Workshop of 1988 and to present him with this deserved honor.

The workshop was a huge success in its own right. When coupled with the beauty of the Franconian region along with the social and cultural program arranged by the Director, the conference was truly outstanding. I am certain that all workshop participants agree with my assessment of the 1988 NATO-ARW-DIMRP and that they also look forward to participating in future NATO-ARW meetings at the Kur-und Kongresshotel Residenz in Bad

Windsheim.

B.3 DIRECTOR'S FORWARD

(by Wolfgang-M. Boerner, preparation of text initiated immediately after the Workshop and completed in principle by **1989 May**, with only minor adjustments, thereafter)

This foreword deals exclusively with the planning, organization, and execution of the Workshop's scientific as well as cultural programs. It is opened with a synopsis on how the global political changes that occurred immediately after the Workshop caused the delay in producing the proceedings, followed by a brief exposition on need, timeliness, and importance of this second ARW in the field of electromagnetic imaging, radar remote sensing, and target versus clutter discrimination; and an outline of the objectives. An informal discussion about some of the organizational details, a retrospective summary of events, and a preview of the third workshop, planned for 1993 September 19-25, is intended to recapture the spirit of this second NATO Advanced Research Workshop (1988 September 18-24), and will reveal how successful it was in comparison to the first of 1983 September 18-24, how its accomplishments may be appreciated and why a third and last workshop was requested by its participants to take place during 1993 September 19-25.

B.3.1 Synopsis

This second NATO-ARW organized by the same Planning Committee has taken place at the last peak of the post-WW-II Cold War period, and during one of the fiercest NATO military manoeuvers Western Europe ever had seen, the Reforger Exercises of the 1988 late summer and early fall, culminating in and around Bad Windsheim; at a time when an equally ferocious Warsaw Pact manoeuver extended through Poland straight to the Iron Curtain, which at that time, was as permanent as Erich Honecker still claimed a year thereafter, on the fortieth anniversary (October 1989) of this "Socialist Prison: DDR", within the heart of Europe. Every single one of us participants of this Workshop, together with the citizens of Central Franconia, was confronted with the reality of an impending WW-III as if it were glaring nakedly at us with all its nightmarish horrors. During our scientific/cultural tours, our busses had to divert into the ditches in order to create sufficient space for heavily armored vehicles, tanks, short and medium range rocket launchers, the bulky HMMWVs (High Mobility Multi-purpose Wheeled Vehicles) and never-ending convoys of military support vehicles of US, French, German, and other NATO defense forces. Yes, in Bad Windsheim, during our stay some of us became witnesses of fatal casualties, several Franconian citizens were killed, and extensive roads, bridges, and also fields with crops just ripe for harvest, were utterly destroyed. In summary, we were given a rather realistic picture of what was to be expected in case the Cold War would further escalate.

In light of the attempts by then still amenable, highly respected UK Prime Minister Margaret Thatcher, and then still USSR Secretary General Mikhail Gorbachev for easing the post-WW-II Cold War tension, these oversized maneuvers on both sides of the Iron Curtain, marking the politico-seismic rift zone between East and West of the time, appeared to us not only ridiculous, but utterly out of place. The resulting lively cross-cultural discussions in the basement lounge after "DAY'S END," among our European, US/Canadian and Asia-Pacific participants, asked for a subtle

change in global Cold War attitudes, and it made many of us "crusaders for an end to the Cold War period" and "fighters for the preservation of our achieved standards of civilization, religions, and cultures – developed over milleniums of human hardship, suffering and persistent struggle," which are being threatened by the nihilistic "USSR Socialist" ideology.

Thus by the end of the workshop and thereafter, some of us got heavily involved in bilateral East-West rapprochements which gathered daily in momentum culminating in repeated time- and energy-absorbing visits to Eastern block countries and in the visit of USSR and other Eastern block experts to the "Capitalist West" and especially to UIC-EECS/CSL. As a result of all these many international research travels and the time-consuming post-event reporting, the completion of the manuscript of the Proceedings of this NATO-ARW-DIMRP'88 got delayed successively more, for which I request, as editor of the Proceedings, my sincerest pardon.

Yet, in retrospect, let me share with you some of the very mindboggling observations and my deep felt conclusions. As was stated incorrectly in the concluding remarks of the Workshop Discussion Group Final Session [IX-7] by Dr. Tapan K. Sarkar et al., the Workshop Director "sometimes extends the cultural aspects beyond the limit of analyticity"! Namely, after what we have now repeatedly experienced and seen existing in true reality during our visits to the Eastern block countries including Poland, East Germany (DDR), Czechoslovakia, the USSR and PR China, where civilization and with it the regional cultural and religious bases were annihilated, there just cannot be any exaggeration – and, for what other global goals are we struggling but to preserve our global environmental and cultural basis of existence and to carefully expand on it. Therefore, I consider it absolutely necessary and certainly worthwhile to instill the high values of defending mankind's past achievements irrespective of its cultural or religious origins also, and especially during our NATO Advanced Research Workshops. Thus, may all of you view the execution of these important scientific-cultural events in the light of "global planetary environmental and cultural defense" to which our series of workshops is intended to be contributing profoundly.

B.3.2 Rationale

In adherence to the workshop programme and schedule objectives worked out for the first NATO-ARW for planning and execution of 1983 Sept. 18-24 in this series, also for the second workshop of 1988 Sept. 18-24 a rather ambitious program with a densely packed schedule was prepared. Essentially, the same organizational committee was retained with the addition of Dr. Ernst Lüneburg replacing retired Dr. Martin Vogel of DLR, Oberpfaffenhofen; and of Professors Dino Giuli, Werner Wiesbeck, Major David E. Stein and of Dr. Frédéric A. Molinet with whom several well functioning short course lecture series in France, Italy, FRG and the USA were conducted since 1983.

The response to our proposal for a second workshop was overwhelming, and we obtained immediate requests for participation in this planned or similar future ARWs by more than 200 renowned scientists in closely related fields. However, upon request by the NATO-ARW-PANEL we had reduced the size of the second ARW for 1988 Sept. 18-24 to only sixty invitees of NATO-member countries so that experts from as many NATO-member countries as feasible could join, in addition to several experts from Austral-Asia-

Pacific Rim allied countries.

All invitees approached guaranteed participation for the duration of five complete working days. The lecture and time schedules were so arranged that optimal interaction among the various participants was possible. There were no simultaneous lectures scheduled. The scheduling of the six workshop groups was so arranged as to allow for active interaction among groups, and the exchange of ideas among the groups was strongly promoted. The chairperson of each workshop discussion group was given special goals to meet and was requested to inform participants about detailed program objectives well in advance of the workshop and by July 1988. The main purpose of this Advanced Research Workshop was to provide a FORUM for international experts to expand interaction and to enlarge the scope of activities for promoting and advancing this rapidly growing, new interdisciplinary field of "Direct and Inverse Methods in Polarimetric Radar Theory, Scattering, Metrology, Calibration, Data Processing and its Applications". (It was, however not intended to be misused for family gatherings or for having a paid-for vacation round-trip of Central Europe). The organizing committee also desired to ensure that participants from as many NATO-member as well as allied countries from the Far East could join in this event for the express purpose of closing the communicative gap between the allied free countries of Europe, America and the Asia Pacific Rim. Also, a first successful attempt was made to include participants from neighboring East- block Poland, Czechoslovakia, Hungary, and from P.R. China.

B.3.3 Need, Timeliness and Importance

This was the second NATO-ARW of the organizing committee in the field of electromagnetic imaging, radar remote sensing, and target versus clutter discrimination. During the first 1983 ARW, inverse methods in electromagnetic imaging were assessed primarily for solving radar scattering problems including mathematical and numerical inversion techniques, signal and image processing with the specific emphasis on the vector (polarization) nature of electromagnetic fields. The resulting two-volume Proceedings are highly praised in the international literature, and stimulating letters from previous workshop participants and many other readers — from East and West — encouraged us to organize this second ARW on a more specific topic. During this second ARW we decided to concentrate on direct and inverse methods exclusively related to radar polarimetry.

High resolution radar polarimetry has most recently become an indispensable tool in modern electromagnetic sensor technology, both in the civil and military sectors, as well as in remote sensing and radar meteorology. From the outset, we wished to emphasize that by incorporating coherent polarimetric phase information into radar signal and image processing, one can anticipate a breakthrough which is at least comparable to that brought about by the advent of holography and computer-assisted tomography and its application to Synthetic Aperture Radar (SAR) and Inverse Synthetic Aperture Radar (ISAR). It will also play an essential role in developing Ultra-Wideband Impulsive Radar (UWIR) theory, metrology and technology urgently required for local and global environmental surveillance of terrestrial and planetary atmospheres and crusts and for the instantaneous detection, ranging, discrimination, and specification of pollutants threatening such environments. Instead of providing an overview of the lecture topics presented during the workshop which are

appended in the second volume of these Proceedings, with a summary of its papers presented in the Opening Paper [O-1] of Volume One; in the following, the functioning of the workshop events will be summarized.

B.3.4 Specifics of Execution of the NATO-ARW-DIMRP'88 in the KuK Congress Hotel Residenz,Bad Windsheim, FRG

The structure of the workshop schedule is very similar to that of the NATO-ARW-IMEI'83 as described in the Director's Foreword of Volume One of its Proceedings. We again met in the idyllic Franconian spa and retreat center of Bad Windsheim, slightly removed from the tourist centers in Rothenburg ob der Tauber and Nürnberg an der Pegnitz. The facilities of both the Congress Hotel and the surrounding Kurpark had been highly enriched since the last workshop, and an exciting hiking and bicycle day-tour program in the surrounding Frankengau, Steigerwald and Frankenhöhe was added.

Again, it was a prime objective of the Workshop Organizing Committee to provide a forum for internationally renowned key experts to expand the interaction, collaboration and scope of their activities in pursuit of this rapidly growing new radar and remote sensing discipline of "Radar Polarimetry." The available guest rooms of the KuK Hotel Residenz and of closely surrounding hotels and pensions within the Kurpark were filled to the brim with a total of more than 160 participants attending some of the key sessions. We were able to assemble all participants under one conference roof so as to allow optimum direct interaction and the ultimate use of a day's working hours (from 7:00 to 22:00 hours). Similar to the first workshop, early (6:00) daily wake-up calls for all participants were arranged for all hotels, have now been accepted as a routine, and this time no loud complaints were made.

We were able to schedule no overlapping sessions, and in total, seventy-five papers were presented. As a consequence, the duration for oral presentation and subsequent discussions was regretfully limited. Therefore, the speakers were strictly advised to use the allotted time optimally (3 min: problem identification; 10 min: succinct summary; 3 min: highlighting relevant contributions; 4 min: discussion). This procedure was well accepted and this time the KuK-Center bell was rarely used for "Call to Order". The main purpose of the presentations was to identify important topics for the workshop Discussion Group activities which, at times, were extended into the evening. In retrospect, everyone will agree that this approach not only worked, but as so many stated in their enthusiastic, positive thank-you notes, it so contributed to optimum information exchange, stimulation of new ideas, to the planning of additional research retreats on highly specific topics, the initiation of long-lasting interaction and cross-continental collaboration among participants who only knew of each other by names or publications, and will now desire to meet regularly in the future. In conclusion, the Organizing Committee wishes to extend their sincere thanks to all those speakers and session chairmen who demonstrated harmonious collaboration for the excellence of paper content, as well as paper presentation and open-minded question handling.

B.3.5 Cultural/Scientific Events

In enriching the overall program, cultural events were scheduled for the evenings on a daily basis in addition to the two main scientific-cultural events of Wednesday, September 21 and Saturday, September 24, 1988.

Furthermore, deliberately on late call, a rather functional spouses program was intelligently improvised again with the dear assistance of Ms. Ursula Allmendinger, Verkehrsamt, Bad Windsheim; by Mrs. Monika Kuehl, UEN, Erlangen; by Ms. Jutta Brockhoff of the KuK Hotel Residenz; by Mr. Johann Schmidt of the Wilhelm Thürauf Reisebüro; and by Mrs. Anita Zierlein, a very knowledgeable multi-lingual tour guide from Rothenburg/oT, and participating spouses, whose inspiration made the cultural spouses shopping, walking and biking tours a memorable event for the accompanients and also for some of the scientists.

The entire scientific/cultural program was planned in detail by the Workshop Director during his tenure as a Senior US Scientist awardee of the Alexander von Humboldt foundation during the winter, spring, and early summer of 1987 (every single bus stop for visits of cultural treasures, scientific displays, meals, shopping and sightseeing walks was painstakenly pre-determined and timed as described below). He was greatly assisted in this function by Prof. Dr.-Ing. Hans Brand, then the dean of Engineering at UEN, his knowledgeable senior assistant, Dr.-Ing. Gerd Schaller of UEN, and their secretary, Mrs. Monika Kuehl; by Dr.-Ing. Siegfried Osterrieder, FHS, Ravenburg; by Dr. Wolfgang Keydel, the director of DLR NE-HF at Oberpfaffenhofen and members of his radar electronics, optics, and remote sensing divisions: Dr. Helmut Süß, Dr.-Ing. Arno Schroth, Dr. Martin Vogel and Dr. Ernst Lüneburg; by Dr. Rudolf Großkopf, Director of the Carl Zeiss Electronics R&D Division, Oberkochen, FRG and by Dr. Wolf-Dieter Teuchert, Dipl. Phys. Hans Werner Flack and Dr. Joachim Heppner, experts of his infra-red and mm-wave sensors divisions; and by Dr. Gerhard Boucke, director of the TST, Radar Electronics Division in Ulm an der Donau and Dr. Gerd Wanielik, Dr. Klaus Solbach, Dr. Werner Sieprath and Dipl-Ing. Jörg Schroth of his R&D sections. The cultural evening programs were planned for in advance with the assistance of Ms. Jutta Brockhoff, the Congress Center managess, Mr. Ralph M. Erlenbach, the hotel manager, and Ms. Ursula Allmendinger, who all went out of their way to help, to advise, and assist us in any way they could. Therefore, we wish to use this occasion to express, on behalf of all the participants of the second ARW, our admiration and gratitude for the thorough and delicate assistance we received during our stay in this pleasant and well developing spa at Bad Windsheim, not only from its friendly citizens during our walks, shopping sprees and visits of the splendid Franconian inns, but, in particular, to the staff and management of the KuK Hotel Residenz. It was especially delightful to meet some faces known to us already from the first ARW during 1983, specifically 'Frau' Eva-Maria Schorr, the head receptionist, and her friendly assistants; 'Herr' Joachim Stein, the head concierge (bell captain); and 'Herr' Gotthard Reiter, the chief cook with his delicately selected team of friendly, attentive waitresses. The cuisine of the KuK Hotel was superb and in comparison to the first workshop, we found that decisive changes had also occurred in the Franconian diet and menu toward lighter meals and plentiful salad bars.

It was a pleasure to be their guests because the excellent service we received again, and the peaceful atmosphere at the elegantly enlarged restaurant enabled us to work hard, yet at the same time, to eat well and to relax in the tastefully selected exercise and swimming facilities of the center. Then, in keeping up with the tradition, after "DAY'S END", a daily increasing number of us disappeared downstairs into the hotel lounge, listening to a well chosen musical trio playing Franconian,

Bavarian, and Czech tunes. The enlarged KuK Hotel Residenz with its varied recreational facilities and the adjacent Kurpark and newly added Herb and Botanic Gardens, provided an ideal stimulating, yet tranquil environment for another work-laden Advanced Research Workshop in Bad Windsheim, lying as it did before, and more so since the unification of East and West Germany into the Federal Republic of Germany of today, in the historical heart of the modern German culture, Franconia.

In the following, some of the highlights of our scientific/cultural events will be summarized with the intention of concluding the description of our NATO-ARW-DIMRP'88 which, again, was a successful, well-rounded scientific as well as cultural experience opening for all of us the cultural border region between the medieval and modern states of Franken and Württemberg/Schwaben through Rothenburg, Dinkelsbühl, Heidenheim/Brenz, Oberkochen, Ulm, Augsburg, and Oberpfaffenhofen near München, where the workshop came to an end on Saturday evening, 1988 September 24.

Sunday Evening Opening Session (September 18, 1988): Preview of Daily Events

Whereas during the NATO-ARW-IMEI'83 the scientific/cultural tours were directed toward the industrial Regnitz/Main regions of Central Franconia (Nürnberg, Erlangen, Bamberg, and Würzburg: Germanisches Museum, Siemens Medical Research Division, Schloß Banz, Mainfränkisches Museum in the Marienburg and the Roccocco Residenz) during the NATO-ARW-DIMRP'88 we selected the Western inter-Franconian-Swabian (Württemberg) industrial corridor (Rothenburg, Dinkelsbühl, Heidenheim/Brenz, Okerkochen: Carl Zeiss, Ulm:TST), traveling along the venerable Romantic Road, Romantische Straße, a commercial trade route dating back to before the Romans. A preview of these events was given after Dr. Günther P. Können presented a most invigorating, lively lecture on "Polarization in Nature" [O-2], with a clear explanation of atmospheric optic polarimetric effects which we observe daily and thoughtlessly take for granted.

Monday Evening Event (September 19, 1988)

Following established tradition, a formal reception by the First Mayor, Mr. Otmar Schaller, and the Second Mayor, Mr. Theodor Michel, at the Historischer Rathaussaal in the City Hall in downtown Bad Windsheim marked the first social event. This time, Mr. Michel, himself a decendant of Huguenotic families, introduced us to the early remodernization period of Franconia at the end of the Seventeenth Century, after the plague had eliminated or almost erased the original population of Central Franconia. It was mainly the protestant Salzburger emigrants from Austria and the protestant Huguenotic immigrants from France who contributed to the restoration of the area; and, the townships of Schwabach, Erlangen, Bad Windsheim and Ansbach had a sizeable French immigrant population of which the Reformed Churches, like the one in Erlangen, are still existing reminders which was of special interest to our French participants. It was a pleasant evening with all of us enjoying the hospitable and cozy downtown inns, and the excellent local Bürgerbräu beer.

Tuesday Evening Event (September 20, 1988)

A very special event was the organ recital on the newly restored pipe organ of the baroque/renaissance church, St. Kilian, in downtown Bad Windsheim. The local organist, Cantor Bernd Uhlmann, took extra efforts to provide tutorial introductions to the functioning, operations, and exposition of this supreme master instrument of European music. He

played selected works of D. Buxtehude, J. Pachhâvel, J.S. Bach and C. Frank in order to demonstrate the versatility and beauty of the pipe organ. Some of us stayed until late into the evening enjoying Cantor Uhlman's mastery. Certainly, such an organ recital at St. Kilian ought to become a highly welcomed event by all participants of future international events of this kind in Bad Windsheim.

Wednesday, Scientific/Cultural Tour (September 21, 1988)

By now, all of the participants of this NATO-ARW-DIMRP'88 were well aware that the NATO Reforger exercises were reaching its climax, with low flying aircraft, booming even during the middle of the night, screeching helicopters from the nearby base at Illesheim and tanks roaring throughout the night. It was like in the war movies. During this Wednesday bus travel to Oberkochen and Ulm, we got into the midst of it: the "blues" chasing the "reds", tanks attacking straight across the highways in front of us ...! To many non-German participants, and especially US and Canadian Americans, who barely ever see any military vehicles on their roads and certainly not rummaging through harvest-ripe fields, this was a true eye-opener on what the "Cold War" is all about, well fitting with the execution of a NATO-sponsored research workshop. It again enticed many of us to look toward some means of putting an end to these non-sensical global war games of destruction. More to the day's events, it put us into the right frame of mind for exploring the superb scientific programs on "night-vision" laser-optical, infrared, millimeterwave and radar remote sensing and battlefield surveillance technology, which then was demonstrated to us at the Carl Zeiss and TST R&D Centers.

We split into two groups, one bus heading for a visit to TST at Ulm, and the other to Carl Zeiss at Oberkochen along the recently completed new autobahn section, Crailsheim-Ulm. Here, we wish to extend a special note of thanks to Carl Zeiss, Electronics R&D Center Director Dr. Rudolf Großkopf and his co-workers, Dr. Wolf-Dieter Teuchert, Dipl- Phys. Hans-Werner Flack and Dr. Joachim Heppner for introducing us to their HI-TECH forefront R&D on thermal sight and night vision tactical surveillance. All of us were very delighted by the pleasing and thought-provoking presentations, the mastery of display technology for which Carl Zeiss was and still is very famed for, but so also were we deeply impressed by the excellence of R&D technology developed here in selected military technologies. Similarly, the other group was highly impressed by the equally outstanding hospitality of the TST Radio & Radar Systems Division at Ulm, where we were welcomed by its Director, Dr. Gerhard Boucke receiving in-depth expositions by Dr. Werner Sieprath on seeker guidance; by Dr. Klaus Solbach on the mostly inhouse developed near-future field antenna measurement range; by Dipl.-Ing. Jörg Schroth in mm-wave device technology in which TST has become one of the European leaders; and by Mr. Karl Fischer, who provided the overview and had arranged the details for our visit. Again, we thank all of the R&D staff, who so well prepared a superb introduction to two of NATO's leading European HI-TECH R&D&E centers, and on behalf of all participants, we extend our thanks for receiving the workshop maps filled with selected meaningful notes on Europe 92, on NATO R&D facilities in Europe, and on FR (West) German research.

After being severely delayed on our bus ride back due to the heavy activity of the Reforger exercises of the day, we turned into "Die Schranne", a newly refurbished meeting hall in a famed medieval "spelt & wheat"

storage elevator at the Weinmarkt, in the heart of Dinkelsbühl ("Spelt hillock"), a renowned medival Reichsstadt (independent empirical state-city), similar, if not more scenic than nearby Rothenburg. We toured the medieval city hall and the famed "high-gothic" St. Georgen Cathedral before being given a "night-watchman's" stroll with trumpeter through the night-lit narrow alleys of the center town to the Spital by Frau Lucas and Herr Wagner, where the "Dinkelsbühl Trio" arranged for an unforget-able evening, playing skits of medieval days. This outing which almost got us bogged down amidst advancing tanks, swerving "HMMWVs" and those never-ending convoys of military trucks, then after all ended on a very pleasant note, and close before midnight, we turned in to the KuK Residenz for a well-deserved rest, though yet with the distant sound of roaring tanks in our ears — all through the night!

Thursday, Late Afternoon/Early Evening (September 22, 1988)
Since our last visit to the Franconian Open Air Museum ('83 September 20), the number of reconstructed original villages, farms, etc. had expanded considerably. It was another enjoyful leisurely stroll at a beautiful sunny afternoon in the mellow Franconian fall atmosphere which remains as the permanent highlight of our memories of this eventful week.

However, the Workshop Director was very disgusted by the unexpected rowdy behavior of some "Kulturbanausen as ever long those come" and especially the rude noise of some lesser-experienced catfish-fresser (s), almost ruining the fine traditional carp dinner prepared diligently according to an original medieval culinary recipe. Such "rude pranks" will not be tolerated in the future and the willful destruction of the workshop director's scientific camera and the removal of the "instrument-to-order" was uncalled for! Yet, after some extra coaxing, we were able to have the "Bad Windsheimer Sänger" rejoin us in spite of the unweildly rude noise just before they packed up, and to regain the festive enjoyful mood which prevailed earlier on during the afternoon. Our deep-felt gratitude is extended to Professor Horst Steinmetz, who, with his capable artists of medieval Franconian musical culture, Georg Föster, Heiner Böe, Fritz Eckardt and Georg Eggermeier introduced us to folk and art songs of the Fifteenth/Sixteenth Century, selecting a set of enjoyful originals created within the vicinity of Rothenburg, Nürnberg, and Bad Windsheim, not duplicating what was presented to us by them during their 1983 presentation.

Friday Evening Workshop Division (September 23, 1988)
After our most experienced, senior participants of NATO-ARWs, Len Cram and Dag Gjessing, had collected the working discussion group reports, marking the end of the lecture and discussion group programs; we assembled once more in the newly enlarged main festivities hall of the Congress Hotel. After honoring some of our distinguished foreign guests as Dr. Zbigniew H. Czyż from Poland, Professors Tsutomu Suzuki, Matsuo Sekine and Kiyohiko Itoh from Japan, Dr. Walter A. Flood and Mr. Jerry L. Eaves from the USA, the Workshop was dedicated to one of our still highly active pioneers, Dr. Jean Richard Huynen. Thereafter, the Workshop director was presented with a new "dingle bell" with the "sound" of the true instrument frozen into an ice block until the next workshop during 1993, September 18-24.

In the final presentation of the evening, Dr. Ing. Siegfried Osterrieder provided a preview of the highlights of Saturday's bus travel along the

"Romantische Straße" with the anticipated stop-overs at Rothenburg, Heidenheim/Brenz and Ulm/Donau; and Dr.-Ing. Arno Schroth delivered a very pleasing preview of the visit to the German Space and Aerospace Research Establishment (DLR) at Oberpfaffenhofen.

Saturday Cultural/Scientific Close-Down Tour (September 24, 1988)

Also during our last day of travel, we got deeply into the Reforger exercises with an unexpected battlefield formation of Medium Range and ICBM launching vehicles forcing us to take major detours into Rothenburg. Therefore, our stop- over in Rothenburg was shortened considerably and another in Heidenheim/Brenz cancelled altogether so that we were able to enjoy one of Europe's largest gothic cathedrals of the Twelfth Century, the Ulmer Dom, with the highest existing gothic steeple added later on. Many of us, next to awing the grandeur of the architecture, of the mighty organ pipes, historical wall paintings, etc., enjoyed the ongoing organ recital on the newly restored mighty pipe organ, one of the most grandious of its kind.

B.3.6 Visit of the German Space and Aerospace Research Establishment (Deutsche Forschungs-und Versuchs-Anstalt f|r Luft und Raumfahrt) DLR-Oberpfaffenhofen, Oberbayern, FRG: Saturday Afternoon

After traversing the Danube and escaping the Reforger exercises, we soon reached Fürstenfeldbruck and then Oberpfaffenhofen to the West of München, where we arrived in time for the scientific program at DLR. We were welcomed by the principal hosts of our workshop, the Director General of this rapidly expanding Space and Aerospace Research and Test Center, Dr. Heinz Häberle, who along with division directors Dr. Wolfgang Keydel (radio/radar systems) and Dr. Manfred Reinhardt (meteorology) introduced us to their very excellent optic, infrared, mm/micro-wave radar-meteorologic measurement, data-processing and image restoration facilities. DLR, until recently known as DFVLR, is the main non-profit German space and aerospace research and test facility with a rich history of scientific accomplishments dating back to 1937, when the Institute for Air Traffic Radio Communications and Radio Navigation FFO (Flugfunk Forschungs-Institut Oberpfaffenhofen) was founded by famed Prof. Dr. Max Dieckmann, then the director of the near-by "Research and Test Station Gräfelfing for Atmospheric Electricity and Wireless Communications: DVG (Drahtlos-telegraphische und Luft-elektrische Versuchsstation Gräfelfing, Obb.)", which he founded as a post-doctoral fellow in 1908. Major German developments of air traffic control, navigation and especially weather forecasting by means of electromagnetic waves were here developed which became the basis of wireless communications during WWI and of radar navigation during WW-II. After WW-II, the entire research instrumentation facilities and the precious scientific library were transferred to the Wright-Patterson AFB, were never returned, and have become a part of the dust-covered inventory of its Air Museum near Dayton, Ohio. Research at Oberpfaffenhofen came to a virtual stand-still until the founding of the Federal Republic of Germany in 1948/49; and after the establishment of its Ministry of Defense (Verteidigungs-ministerium) in 1955, the Institute for Wireless Radio Navigation and Microwave Technology/FFM (Institut für Flugfunk and Mikrowellen) was founded under Prof. Günter Ulbricht. In 1978 it was renamed the INSTITUT FÜR HOCHFREQUENZTECHNIK under its current director Dr. Wolfgang Keydel, a renowned expert in radar remote sensing, formerly at AEG-TELEFUNKEN, Ulm/Donau, now renamed Telefunken System Technik (TST).

Among the European NATO Research, Development & Engineering Centers in electromagnetic sensing and imaging covering the entire non-invasive spectral range, it ranks among the very top at a level as RSRE, Great Malvern, UK; ONERA, Chatillon-Bagneux and CELAR, Bruz, FR; TNO, Scheveningen, NL; and NTNF, Kjeller, NO. Thus, it was indeed a great treat to be invited there and view the superb research instrumentation facilities on a splendid fall afternoon with the characteristic Bavarian blue sky dotted with the fluffy while "baroque clouds" above us, which is symbolically recaptured in the display of the Bavarian flag: Weiß-Blau!

We were sub-divided into four rotating groups after the introductory lectures (one hour) to view (i) the Wideband Polarimetric Target RCS Radar Instrumentation facility (800 MHz - to 45 GHz), **[VI-4])**, (ii) the m-to-mm-wave and infrared radiometric and thermal sensing & imaging division, (iii) the optical & infrared air & space sensors division, (iv) the fleet of Dornier research aircrafts and its ground-based meteorologic instrumentation facilities. Although all expositions were truly exceptionally planned by Dr. Wolfgang Keydel and Dr. Manfred Reinhardt and their staff, the absolute highlight was the introduction to one of the most celebrated new instrumentation additions, **the Wolkenradar Poldirad (C-band Dual Polarization Doppler Radar)**, designed and planned at DFVLR-OPH in collaboration with Electronic Enterprice Corporation of Enterprice, Alabama, USA. Our special thanks are extended to Dr. Arno Schroth, Dr. Herbert Meischner, Dr. Helmut Schuster, Dr. Karl Tragl, Dr. Madhu Chandra and Dr. Gottlieb Schnabl for the very pleasing and informative scientific introduction **[VIII-1]**, **[II-9]** to the Poldirad, and to Drs. Bernd Röde, Ulrich Fuchs and Reinhard Hammel for demonstrating the impressive Wideband Polarimetric Target RCS Radar Instrumentation Facility. To all of the DLR research staff we would like to extend our sincerest thanks for this exciting afternoon, as well as to the truly excellent support staff, Frau Margareth Malchow, Fräulein Gabriele Bierl, and Herrn Reiner Weppner for hosting us before we departed for München-Hauptbahnhof, where the Workshop came to a full-filled end.

B.3.7 Post-Workshop Engagements: The End of the Post-WW-II Cold War, the Unification of Germany and the Break-up of the USSR

As a result of the realities of an escalating Cold War, so vividly demonstrated to all of us by the NATO Reforger exercises, the Workshop Director considered it his prime duty to work toward the de-escalation of these nonsensical all-destructive cold-war-games. The opportunity arose concurrently and he was invited repeated times to Eastern Europe (1988-90), the People's Republic of China (1988/89) and then also to the USSR (1988/89/90/91). In all of these Eastern block countries, we observed a very distinct double-class system, with the Communist Party cadre plus the scientific and technologic establishment replacing the Czarist and similar nobility and living fully separated from the very great majority (85%) of its citizens. Ironically, counter to the original spirit of the Communist's "peasant, laborer and soldier's paradise", the common people are misused more or less as slaves of the system. It is not only a few million Soviet and Chinese citizens that were annihilated, mainly during Stalin's earlier era (1922-1933) and the destructive period of the Red guards, but tens of millions were erased in what amounts to ethnic genocide versus minority groups. More so, the once blooming regional cultures and civilizations as that of the Buryatian and the Evink of Sacred Lake Baikal region were destroyed; synagogues, churches, temples, and spiritual sites totally burned down; and it all replaced by some nihilistic

empty Communist ideology with very little respect for individual rights and none what-so-ever for the preservation of the natural environment and original cultural resources and values.

Certainly, not only the Europeans, but the entire world owes a great debt to the United States, its brave statesmen and citizens, for defending the free world; fully justifying the realities of Cold War as exercised in the Reforger manoeuvers we all experienced so vividly.

However, for many explainable reasons, the Eastern Communist systems are breaking apart very rapidly, and due to the courageous struggles of all Eastern European countries, due to the wisdom of President Mikhail Gorbachev and his co-strugglers within the USSR and that of our NATO statesmen, are we witnessing how the global political Cold War structure is rapidly disintegrating and a rapprochement between East and West is and can now be taking place.

Although we must always be aware of the true serious threat any "nihilistic ideology" still poses to us, we must understand that the East block citizens were and still are imprisoned, have been and are still treated like slaves — and this for about forty-five years, and for more than seventy-five years for those living within today's USSR borders. Soon the "iron curtains" surrounding the East Block will deterioriate completely leading to an explosive mass migration which could reach tens of millions originating from within the current USSR alone by the turn of the century. Unless we accept that such "migration tsunamies" will totally inundate not only North-Central Europe and Austral-Asia, but also America and especially Canada and the U.S., NATO will have to change its approach toward its recent WW-II Cold War enemies totally and completely.

Namely, in order to dampen and reduce mass migration, we must reach out and provide generously expertise not only in rebuilding trade, commerce, business, banking, sanitary facilities (in most part non-existent!!) communal government, etc., but we must at the same time, provide solid education in regional cultural, linguistic and religious aspects because all of these "suppressed" ethnic groups suffered from the complete destruction of their natural habitat, their once generous natural resources, of their civilizations, religions, and cultural bases during their recent episode of "communist imprisonment". Thus, we will have to not only rebuild their economic and industrial bases from scratch, but also develop strong global environmental planetary defense measures, so their entire life's spiritual and religious needs will be slowly regenerated and redeveloped.

As regards the series of these NATO-ARWs on the advancement of "Direct and Inverse Methods in Electromagnetic Sensing and Imaging," it has now been clearly established world-wide that there exists a great need for developing acoustic, electromagnetic, and seismic sensing and imaging methods for the "instantaneous localization, ranging, detection, specification and identification of environmental pollutants" of any kind and source, resulting in the request for another NATO-ARW.

Therefore, in light of all of these changes, our third NATO-ARW in this series will be dealing with "ultra-wideband polarimetric impulsive radar sensing and imaging" in "wide-area electromagnetic surveillance of our terrestrial atmosphere and crust". In order for us to advance this

scientifically very demanding technology rapidly, we will attempt to request participation of a large number of experts residing in regions of the former "Eastern Block" and have them join us during 1993 September 19-25 at the KuK Congress Hotel Residenz at Bad Windsheim, FRG.

B.4 Concluding Remarks

In meeting so many diverse tasks simultaneously, and in guaranteeing a full success for the future distribution of the proceedings for this Workshop, our gratitude foremost is extended to our prime supporters, the NATO Scientific Affairs Division, ARW Programmes; and, here, very special thanks are extended to the late Dr. Mario DiLullo, under whose directorship the planning for this second ARW was initiated, and to Dr. Craig Sinclair who continued with the encouraging and always enthusiastic approach until he was replaced after his retirement recently by Dr. Giovanni A. Venturi and then by Dr. Luigi Sertorio, who also showed deep understanding for our approach. Similarly, we wish to thank Dr. Walter A. Flood, US Army Research Office, Dr. Karl H. Steinbach, US Army RDSG (UK) and Dr. Wolfgang Keydel, DLR NE-HF, for their extensive financial and moral support. Last but not least, we wish to thank both Dr. Tilo and Mrs. Barbara Kester of the NATO Publication Coordination Office and our publishers Mrs. Nel M. Pols van der Heijden and Mrs. Nel de Boer of Kluwer Academic Publishers/D. Reidel, for their continual encouragement and advice.

A very special note of thanks is directed to Mrs. Monika Kuehl (UEN), Ms. Gabriele Bierl (DLR); especially and foremost, to Mr. Reiner Weppner (DLR) for their dilligent handling of the financial matters during the entire pre-to-post-workshop periods. Without the brillian managerial and organizational talents of Mr. Reiner Weppner (DLR), the entire workshop reporting to NATO-SEAD could not have been completed in time.

The preparation of these Proceedings was again strongly facilitated by the superb managerial and secretarial capabilities of Mr. Richard W. Foster and also by Major David E. Stein and Dr. Ernst Lüneburg who assisted us in many extra hours in the completion of this enormous task.

Again, my understanding wife, Eileen Annette and our children (Vaughan, Allan, Jo(h)anna), deserve my deep appreciation for their patient tolerance of the many pre- and post-workshop travels, the many long nights and lost weekends of extra hours, often far from home, during the entire pre-to-post workshop engagement for the past five (5) years.

4.C PREPARATION & EDITING OF WORKSHOP PROCEEDINGS

C.1 OUTLAY OF PROCEEDINGS TOPICS WITH SUMMARIES

The specific objectives of this NATO-ARW are to advance direct and inverse methods exclusively related to radar polarimetry including every single presentation as described in the Director's Forward. Although considerable R&D efforts had been expanded during the past decades, and primarily since the NATO- ARW-IMEI'83, there still exist many "grey areas" in both theory and techniques of radar polarimetry which were chosen for consideration during this NATO-ARW-DIMRP'88, covering the meter-to-submillimeter wavelength, infrared and also optical regions of the electromagnetic spectrum. The emphasis was placed on the basic principles of electromagnetic wave interrogation with natural and/or man-made media and objects, the optimal selection of illumination and sensing, the optimal recovery of useful target signal, mathematical and data processing methods, and representative applications.

The complete proceedings of this NATO-ARW-DIMRP'88 are collected in two parts. A perusal of the Table of Contents (Attachment 7.3) reveals the diversity of topics presented, ranging from mathematical expositions, metrological approaches, experimental results to computer-numerical methods of vector signal/image processing and its applications. For such a rapidly developing research area, it is necessary to classify the progress reported here approximately according to topics, of which we identified basically eight and collected about ninety-two papers in separate topical sections plus an introductory overview and a working discussion group activities reporting section. This arrangement, in ten sections - with Topics **O - IV** contained in **Part One**, and Topics **V - IX** in **Part Two** - will enable the reader to become acquainted with the current research trends.

C.2 POST-WORKSHOP CONTRIBUTIONS

Since the execution of NATO-ARW-IMEI'83 and NATO-ARW-DIMRP'88, the potentials of polarimetric radar target phenomenology have been recognized worldwide as is evident: (i) from the large number of recent workshops, retreats and coordinated topical/special symposia sessions on **"Direct and Inverse Methods in Radar Polarimetry"**, and on **"Polarimetric Radar/Scatterometer/ Synthetic Aperture Radar Data Processing and Applications"**; (ii) from the large body of new books on the subject matter such as for example by Mott [48], Ulaby, Fung and Moore [49], Ulaby and Elachi [50] and Kong [51]; and (iii) from the increasing number of international measurement campaigns and closely related experimenters and data processing retreats such as the Joint NASA/ESA/ISAS Polarimetric Radar/Scatterometer /SAR Calibration Workshop at DLR-Oberpfaffenhofen FRG, rescheduled due to the Mid-East crisis from 1991 January 25-30 to 1991 October 9-18. We are confident to state that these increased activities were, in major parts, stimulated by (i) the IEEE Ant & Prop, Special Issue March 1981 (Vol AP-29) on "Inverse Methods in Electromagnetics" [8], (ii) the three Polarimetric Technology Workshops of MICOM, Redstone Arsenal/Huntsville, AL planned, organized and executed primarily by L.W. Root and coworkers [9, 29]; and (iii) the first NATO-ARW-IMEI'83 [7] as well as by our NATO-ARW-DIMRP'88. We refer the reader to the resulting proceedings, and also to those of other pertinent workshops such as CCG/DLR-86(87-89) [52], at Oberpfaffenhofen, FRG; PRWL 89 in Leningrad, USSR [53, 57]; JIPR'90 [54, 59] at Nantes, FR and also the proceedings of the recent IEEE/AP-S and IEEE/GSRS-S International Symposia plus URSI North American Radio Science Meetings, the European Microwave Conferences and of the Asia-Pacific

Microwave Conferences since about 1986.

As regards the pure and applied mathematical treatments of Inverse Scattering Theory, we refer to the annually reoccuring workshops RCP 264 (Rencontre Interdisciplinaire Problèmes Inverses) organized every year in late November/early December by Professor Pierre Célestin Sabatier at USTL, Montpellier, France [54]. In cyclic order the emphasis of these exciting, research stimulating get-togethers focuses every year on different application areas and scientific issues of inverse problems.

Here, another two specific recent applied workshops deserve the attention of the readers; and their main scientific events are briefly summarized:

1989, May 13-May 26 Leningrad, USSR Meeting on "The Advancement of Inverse Methods in High Resolution Polarimetric Radar Imaging and Its Application to Hostile Object Discrimination Against And the Remote Sensing of Terrerstrial and Planetary Atmospheres" [53].

Upon the initial assistance of Dr. Zbigniew H. Czyż, Warsaw, Poland, contact with polarimetric radar experts via Prof. Pyotr Yakobovich Ufimtsev, USSR Academy of Sciences, Institute of Radioengineering and Electronics, Moscow, USSR, a first get-together was arranged by Dr. Gennady N. Gromov of the All-Union R&D Institute for Radio & Radar Systems, Leningrad, USSR during 1989, May 13-26. It was a series of very lively presentations also by the famed radar polarimetrists Prof. Vladimir A. Potekhin, Prof. Anatolij I. Kozlov, Prof. Radij V. Ostrovityanov, Dr. Dimitrij B. Kanareykin, Dr. Victor N. Tatarinov, Prof. Arkadij B. Shupyatsky, Dr. Levitan A. Zhivotovsky, Prof. Boris Sh Lande, Dr. Valdimir D. Stepanenko, Dr. Aleksander V. Ryzhkov, Prof. Aleksander I. Logvin, Dr. Konstantin G. Tskhakaya, and other famed polarimetric radar meteorologists and applications specialists from within the USSR. It was very apparent that radar polarimetry within the USSR had been advanced very strongly especially since the appearance of Dr. J. Richard Huynen's dissertation monograph in 1970 [31](which is referenced already in 1972 in various Russian papers). Unfortunately, no commercially available translations of most of their monographs and books exist; therefore, the Workshop director requested from them the preparation of two review papers for these Proceedings **[O-3 and O-4]**. Furthermore, as a result of this Leningrad May 1989 PRWL meeting [53], and during a brief stop-over of 1989 November 10-11 in Moscow [55], a reciprocating visit of several radar polarimetrists of the USSR to the 1990 May 05-11 IEEE/AP-S & MTT-S plus URSI-NARSM at Dallas,TX [56] and the 1990 May 14-17 SPIE Polarimetry Conference [24] at Huntsville, AL was negotiated. It resulted in the visit of Profs. Anatolij I. Kozlov and Aleksander I. Logvin of the Moscow University of Aeronautical & Space Science & Technology; of Prof. Arkadij B. Shupyatsky of the USSR Central Aerologic Observatory, Dolgoprudny; of Dr. Aleksander V. Ryzhkov and Dr. Sergey Yu. Matrosov of the Main Geophysical Observatory, Leningrad; and of Profs. Levitan A. Zhivotovsky and Radiy V. Ostrovityanov from the Leningrad Universities of Radioengineering LETI (named after Lenin: V.I.Ul'yanov) and Naval Electronics, respectively. Eighteen (18) major papers were presented by our guests during their two-weeks first-time stay in the USA of which several were re- edited and expanded for inclusion in these proceedings (**[II-8], [IV-3], [IV-10], [VI-9], [VIII-10]**). This rapidly intensifying interaction was further advanced by the recent participation in the Joint US-USSR Global Environmental Preservation Program on "Save the Terrestrial Large Lakes: Baikal/Michigan Environmental

Theatre Festival with Ecological Research Retreats", Ulan-Ude 1990 Aug 18 - Sept 04 [57] during which joint polarimetric radar research and POL-SAR measurement campaigns (USA:JPL - FRG:DLR - USSR:ASREI - JAP:ISAS/NASDA) were initiated in coordination with Dr. Namzhil B. Chimitdorzhiyev, USSR Academy of Sciences, Siberian Division, Buryat Region, USSR [58]. Members of this Buryatian boreal environmental remote sensing research center were revisiting the USA during 1990 December for preparing the 1992 July event in coordination with the URSI-NARSM and IEEE-AP-S Symposium in Chicago, IL/USA, 1992, July 18-25.

As is clearly stated in the resulting travel reports [53-57], it is this bilateral USSR-NATO interaction which is desperately required to develop the badly needed advanced HI-TECH in **"Ultra-wideband Polarimetric Radar Sensing & Imaging of the Terrestrial and Planetary Atmospheres and Crusts"** for the **"Instantaneous Localization, Ranging, Specification and Identification of Pollutants, its Sources and Transmitters"**. It is the very definite objective to deal with these timely and important **"global environmental planetary defense"** issues henceforth and especially during the third NATO-ARW in 1993, Sept. 19-25.

In concluding this Sub-section, the author of this report states with pride and confidence that his at times daring and non-conventional approach to ensuring that (i) the Iron Curtain dividing his home country and thus also separating his relatives into the "FREE WESTERN" and imprisoned "COMMUNIST EAST" remnants of the YALTA/POTSDAM agreements be torn down, (ii) a rapid rapproachment between Eastern and Western Radar polarimetrists be visibly strengthened; and (iii) a true end is made to "LENINIST-MARX-ENGEL-COMMUNIST" suppression of the human mind, was indeed crowned with high success as is documented in appended reports and material.

C.3 DETAILED CONTENTS OF PROCEEDINGS

In the following a summary of the contents of the Proceedings papers is given in context with recent developments in radar polarimetry.

- PART ONE -

C.3.0 Historical Trends and Overviews: Topic O

Reviews of pertinent direct and inverse methods used in Radar Polarimetry with historical developments, current trends in both Western and Eastern countries are assessed for the identification of the current state-of-the-art.

First, an attempt is made of providing an up-to-date review and assessment of direct and inverse methods in radar polarimetry together with those of recent events culminating in the overview for these proceedings **[O-1]**. It is followed by the "Keynote Address" on"Polarization in Nature" by Günther P. Können **[O-2]**, the famed Polar (Arctic & Antarctic) Atmospheric 'Polarimetrist'; by two special post-workshop invitations to our radar 'polarimetrists' from the USSR, each providing one state-of-the-art -review on fundamental developments **[O-3]** and on applications of radar polarimetry to meteorology, oceanography and planetary remote sensing **[O-4]**, by a succint review on meteorologic weather radar polarimetry in North America **[O-5]**, and concluded with a comparison of fundamental approaches to radar polarimetry **[O-6]**.

C.3.1 Basic Polarimetric Radar Theory: Topic I

Although the polarization properties of electromagnetic waves are well understood [20,23,48], various unresolved questions, both in theory and application, are addressed for the coherent, partially polarized and partially coherent cases. Fundamental hitherto unknown issues, such as polarization sensitivity of SEM (Singularity Expansion Method) and EEM (Eigenmode Expansion Method) and time-domain polarization descriptors are identified.

There definitely exists a great number of truly deserving invitees based on their past and recent contributions to radar polarimetry; and we were very delighted to have a few of them join us, for instance Professor Harold Mott, one of the most recent book authors on the subject. He was given the topic of introducing the basic definitions of polarization in the opening paper [I-1], which is followed by that on basic equations in radar polarimetry of Boerner et al [I-2]. Our Eastern-European Dr. Zbigniew H. Czyż struggled with the formulation of alternative fundamental approaches [I-3] and the newly appointed Prof. Shane R. Cloude with the uniqueness of target decomposition theorems in radar polarimetry [I-4], first introduced by Dr. J. Richard Huynen to whom these Proceedings are dedicated [I-7]. His unique discovery and formulation of the **"Polarization Fork"** concept, derived from E.M. Kennaugh's original work, to which the first NATO-ARW-IMEI'83 [7] was dedicated, is readdressed in the companion papers [I-5] and [I-6] comparing two entirely different approaches converging, as they should, in the same results.

Because the workshop director is of the opinion that the broadband partially polarized case can still not be broached satisfactorily; instead of further pursuing the controversial subject of **"Huynen's decomposition theories"** (see papers [IV-2] and [III-12] of the previous Workshop Proceedings [7], and [II-5] of these Proceedings), here the question of wideband polarimetric radar vector signal analysis is being considered by Sarkar et al, first introducing the T-Pulse concept [I-8], based on Kennaugh's original Kill or **"Kennaugh"-Pulse** concept [8], and then by Baum, who is analysing the polarization dependence of the SEM and EEM Scattering matrix in wideband radar vector signal processing [I-9]. This topical Section (I) is concluded in a novel approach by Chamberlain [I-10] of dealing with "transient polarization" aspects, a topic of growing vital importance to the rapid advancement of "ultrawideband polarimetric impulsive radar vector signal processing" [61], to be investigated in depth during our forthcoming third workshop NATO-ARW-WPDR'93 [IX-8].

C.3.2 Polarimetric Scattering Theories: Topic II

Analyses of geometric and physical optics inverse scattering theories and their relevance to polarimetric radar target phenomenology are still ongoing and will have to be further advanced for a long time to come. Specific emphasis is placed during this NATO-ARW-DIMRP'88 on the extensions of the Kennaugh-Cosgriff transient ramp response methods to the slightly bistatic case and its applications in polarimetric target phenomenology and remote sensing.

The topic of polarimetric scattering theories, briefly broached in [I-8] to [I-10] from a low-frequency wideband interpretation, in this topical

Section (II) is exclusively handled from the Geometric Optics (GO) and Physical Optics (PO) viewpoints as introduced in the well done overview by Dr. Alon Schatzberg [II-1]. Here, the underlying concept of polarization correction of backscattering from conducting smooth convex surfaces is assessed which is based on Kennaugh's original work, reproduced here in the commemorative paper [II-3], and the research endeavors of the workshop director and his students in extending the results to the bistatic case as well [II-2]. Chaloupka, who together with his able doctoral students also contributed profoundly to these investigations, is expanding on both the PO/GO and GTD (Geometric Theory of Diffraction) inversion via polarimetric linear prediction [II-4], and the related paper by Chaudhuri, Foo and Boerner [II-5] is displaying some interesting features of Huynen's Mueller matrix parameters in applying the polarization corrected PO results derived in [II-2] for the monostatic and slightly bistatic cases. Huynen presents a conjecture on how to approach the "torsional parameters" in his Mueller matrix decomposition theory in [II-6] which yet requires a satisfactory mathematical proof and physical verification. In a very industrious post-workshop invitation, Dr. Volker Stein puts together on what hitherto has been accomplished in polarimetric scattering theory and how it may be applied in numerical modeling [II-7]. Pertinent contributions by the polarimetric target/clutter modelers Kozlov and Logvin of the Moscow University of Aviation & Aerospace Science & Technology are summarized in [II-8], whereas Dr. Karl Tragl develops an elegant extension of these polarimetric scattering theories to the determination of optimal polarization states for reciprocal random targets applicable to meteorologic radar backscatter description [II-9]. We refer here also to his excellent dissertation [62] dealing with a co-variance matrix optimization procedure. A polarimetric model for multipath imaging and scrutinization, based on polarimetric GO/PO scattering theory extensions by Chaudhur and Boerner [II-10], rounds off this topical section (II) providing input for the analysis of polarimetric multistatic broadband inverse scattering approaches which are to be assessed during the forthcoming NATO-ARW-WPDR'93 [IX-8].

C.3.3 Polarimetric Metrology & Systems Calibration: Topic III

The design of the optimal polarimetric radar system still requires resolution of several questions pertaining to basic polarimetric radar metrology including proper standardization of measurement procedures for scattering matrix measurements, polarization state transformation, dual polarization antenna measurements, etc. Also, the questions of designing the most suitable set of calibration targets as well as defining proper pre/in/post-flight calibration methods are still not resolved as is discovered — in parts — in this section.

Since the test-bed design attempts of the first dual polarization radars by Kennaugh [26], Huynen [30], Gent [28], van Etten [63], Nathanson [64], Poelman [65], Eaves [33], Root [29] and many more; persistent drives by Lloyd W. Root, particularly in recent years, brought about a subtle change in device technology as reported primarily in three recent MICOM Polarimetric Radar Technology Workshops at the (Wernherr von Braun) Rocket Auditorium within Redstone Arsenal [9,29]. Associated with these mindboggling advances are the innovative new approaches to polarimetric metrology and polarimetric systems calibration which elevated radar polarimetry to a mature engineering science discipline in remote sensing and high resolution imaging during the 'eighties'. Professor Werner

Wiesbeck and his many able, enthusiastic doctoral students delivered a fine introduction in [III-1] to the subject matter which is followed by another brilliant contribution of Dr. Shane R. Cloude [III-2] all dealing with m-to-sub-mm wavelength analyses of polarimetric scattering matrix measurements, of which a systematic measurement error evaluation scheme is provided in [III-3]. Interspersed are the papers by Prof. Rasheed M.A. Azzam and Prof. Walter K. Kahn and students on efficient metrology and calibration in the optical [III-4] and the microwave [III-5] spectral regions, followed by a meditative analysis on reciprocity by Feinstein [III-6], a topic that stirred up a lot of heated commotion during the various Workshop discussion group activities (see [IX-4] & [IX-5]). The "factotum non comparis" of our workshop, the highly esteemed, dynamic Lloyd W. Root, contributed a humorous and witty summary on his innovative pioneering efforts of developing the concept of "Active Polarimetric Calibrators" and of demonstrating practical calibration results [III-7] which since have been copied ruthlessly by many without mentioning the originator's name. The last three papers of this topical section (III) are dealing with various aspects of system metrology and calibration of POL-RAD [III-8], POL-SAR [III-9] and combined [III-10] systems aspects. Every single paper of (Topical Section III) contributed profoundly to the lively discussions of the entire working discussing group efforts W-A to W-E and also to W-F in that obvious discrepancies in the usage of nomenclature, symbols, concepts and standards become blatantly apparent as highlighted in every report of [IX-1] to [IX-7], and to be reassessed during the third NATO-ARW-WPDR'93 [IX-8].

C.3.4 Polarimetric Vector Signal Processing: Target versus Clutter Discrimination: Topic IV

Provided that the scattering matrices are known on a POL-RAD bin-by-bin, POL-SAR pixel-by-pixel basis, novel robust signal and image processing tools are feasible and are being introduced in order to display the rapid advancements made.

Closely related with the topic of metrology and calibration (III) is that of "Polarimetric Vector Signal Processing" in polarimetric sensing and imaging with direct application to optimal target versus clutter discrimination, being the topic of this section (IV). The first paper is by the author of the now famed review on "Polarization Diversity in Radar of 1986" [44], Prof. Dino Giuli and his senior assistant of the University of Florence, Italy providing an up-to-date overview on Polarimetric Signal Processing Techniques [IV-1]. Here, we add that after this workshop came to a close, Prof. Dino Giuli has introduced another very important contribution to realizing "instantaneous recovery" of the 2x2 Sinclair scattering matrix parameters by using an orthogonal ambiguity function approach for simultaneous dual polarization radar measurements [VI-10] as will be discussed in detail during a special session of the forthcoming PIERS' 91, and more so during NATO-ARW-WPDR'93. Similarly, the next three papers by Wanielik [IV-2], Zhivotovskij [IV-3] and Sekine [IV-4] deal with novel multi-dimensional concepts of dual polarization radar signal processing which deserve our full attention including Sekine's polarimetric Weibull radar clutter modeling approaches (see Topic IX-1, reference [48]). Following the exposition of Preiser on "Adaptive Radar Polarimetry" [IV-5], which strongly reflects on earlier studies by Compton [67] and Fujimoto et al [68] on the subject matter; Wanielik, in another well done presentation, introduces his very ambit-

ious and complex novel approach to a "Polarimetric CFAR-detector"[IV-6], stimulating extensive future investigations on Poelman's recent true original contribution of the "Multi-notch Logic-product Polarization Filter" approach for enhancing automated instantaneous target detection in severe dynamic background clutter [34,65]. It was most sincerely regretted that Poelman was prohibited from taking part in this NATO-ARW-DIMRP'88 due to internal restructuring of his home base in order to present another innovative contribution [69] which was finally released for inclusion in these Proceedings under [VI-6]. Now, we strongly request his participation in the forthcoming NATO-ARW-WPDR'93 addressing primarily the advancement of "Optimal Polarimetric Multi-Static Wideband Low RCS Target Detection in Severe Dynamic Background Clutter". The next two papers deal with the assessment of in-house polarimetric discrimination algorithm developments at GTRI-RAIL by Holm [IV-7] and at Selenia by Farina et al [IV-8]. A very interesting paper was contributed by Dr. Pax Samuel P. Wei of Boeing Aerospace, Kent Space Center dealing with scattering matrix analyses in a non-reciprocal magneto-ionic medium [IV-9], followed by another exposition of Logvin and Kozlov on optimal processing of polarization of higher order harmonics generated by electromagnetic wave interaction with non-linear materials [IV-10].

In concluding this Topical Section (IV), we need to refer to the two review papers [O-3] and [O-4], in which other recent very outstanding contributions of radar "polarimetrists" from the USSR are cited, and especially those of Potekhin, Kanareykin, and Tatarinov deserve our fullest attention as will become evident during NATO-ARW-WPDR'93, and here we refer to Section V of this introductory paper [O-1] in which the events 92-2 and 92-3 next to 93-1 are most pertinent.

- PART TWO -

C.3.5 Vector (Polarization) Diffraction Tomography & Environmental Sensing: Topic V

Imaging in inhomogeneous media requires the generalization of straight-line projection tomography to diffraction tomography by satisfying at least the Rytov-Born approximations. In case the true depolarizing terms ($\nabla\varepsilon/\varepsilon$) and/or ($\nabla\sigma/\sigma$) can no longer be neglected in the inhomogeneous wave equation, a further extension to vector diffraction tomography is required. Applications to the detection and imaging of concealed and buried objects in strongly inhomogeneous media are discussed.

The first two papers are presented by Prof. Karl J. Langenberg [V-1] and Prof. Pierre Célestin Sabatier [V-2], who recently together with G.T. Herman and H.K.Tuy contributed the outstanding tutorial research text on **"Basic Methods of Tomography and Inverse Problems"** [70], here, however focusing on the polarimetric aspects of the multi-dimensional problem in inhomogeneous propagation space; a problem which was also discussed violently during the Working Discussion Group W-C activities [IX-3]. More practical aspects of microwave and ultrasonic imaging are considered by the expert team of SUPERLEC [V- 3], a preliminary analysis of "de-polarizing effects" in vector(polarization) diffraction tomography is attempted in [V-4], and more recently further advanced by the workshop director and students in [71]. The remaining six papers of this topical section all deal with the implementation of polarization dependent tomographic principles, where in [V-5] Prof. Jürgen Detlefsen of the famed TU München,

Microwave Research Laboratory demonstrates practical results of a 94 GHz imaging radar for autonomous vehicle operation. Dr. Robert H. Giles et al, consider the related problems of submillimeter wavelength modeling of dielectric materials in polarimetric interferometric imaging radar approaches [V-6]. In [V-7] diffraction limited polarimetric backscatter by rough terrain surfaces is discussed. The next three papers deal with polarimetric sensing and imaging of "volumetric scattering scenarios" such as on underground radar imaging by famed Professor Tsutomo Suzuki and students of the Electro-Communications University at Chofu-Shi, Tokyo/Japan [V-8]; polarimetric microwave remote sensing of surface and volumetric subterranean terrain scattering by Prof. Jin-Au Kong and former students [V-9]; and, is concluded with a comparative assessment on the dynamic modelling of volumetric sea-icescatter and its dependence on geophysical ground truth parameters by Dr. Dale P. Winebrenner and his professor, Leung Tsang, and colleagues of the renowned University of Washington, Applied Physics Laboratory, Oceanographic Imaging Division, in Seattle, WA/USA [V-10].

In concluding this topical section (V), we need to refer to the proceedings of other related workshops of the URSI Int'l Commission F, Wave Propagation Symposia and of those of PIERS 87/89/91 in relation to applying some of these important topics to polarimetric remote sensing [51] utilizing POL-RAD/SCAT and POL-SAR/ISAR measurement systems as was further pursued during the working discussion group activities W-B [IX-2], W-C [IX-3], W-D [IX-4] and in W-E [IX-5] as regards the development of proper standards, and in W-F [IX-6] as relates to current and future inter-NATO country joint measurement campaigns.

C.3.6 Polarimetric Radar (POL-RAD) Systems Design and Operation: Topic VI

In order to deploy polarimetric radar systems in practice, one requires polarimetric channel isolation of about 35 dB or more, sidelobe reduction of about 30 dB or better, etc. In addition, we require that the polarimetric antenna state switching is reciprocal and the radiation patterns are polarization state isotropic. Some of the recent advances on how to achieve these and similar goals and how to assemble state-of-the-art dual polarization radar systems are discussed.

The papers of this topical section describe a variety of recent polarimetric test-bed instrumentation radar systems, presenting the state-of-the-art of the late 1980s, and with the current rapid advances made in device technology, these soon may seem to look like "pre-historic, large beasts" of "unwieldy collossal radar systems". Nevertheless, for the purpose of integrating practical aspects with metrology and calibration and also with theory and signal processing, the inclusion of this section was considered most vital. The workshop director considers the integrated multi-level theory-metrology-information-technology approach an absolute necessity for advancing this complex trans-disciplinary field; and, theoreticians are especially invited to not only peruse the papers of this section but to have a true thorough look at them in order to be able to focus on the inherent technologic complexities and current limitations of realizing some of the more "utopic polarimetric algorithm" implementations.

The description of the RADC POL-RAD System, [VI-1], so well presented by Ken Stiefvater and well defended during the working discussion group

activities **W-D [IX-4]**, **W-E [IX-5]** and **W-F [IX-6]** is about the top of the current-state-of-the-polarimetric-technology. Similarly, the RSRE/THORN-EMI **[VI-2]**, the UKAN [VI-3], the DLR [VI-4], the RAT-SCAT **[VI-5]** and the SHAPE-TC **[VI-6]** systems descriptions well illustrate the true progress made in polarimetric radar system technology as well as in the professional operation and calibration of such systems. The paper on integrated micro-strip polarimetric patch antenna devices **[VI-7]** by one of its true pioneers, Prof. Kiyohiko Itoh, is applicable to direction-finding and these polarimetric integrated, fast-switching antenna approaches will soon allow the implementation of real-time polarimetric doppler radar processing and operation in practice, which are so urgently required in severe storm and tornado prediction [81]. Whereas, the well received papers on "polarimetry-dependent angulometry" by renowned polarimetric scatterometrists Prof. Dag T. Gjessing and Dr. Fan-Nian Kong **[VI-8]** and its relevance to glint-suppression by famed polarimetric radiometrist Prof. Radiy V. Ostrovityanov **[VI-9]** demonstrate the true capabilities of circumnavigating the inherent limitations of the classical non-polarimetric radars, and the venerable ground/ship-based mono-polarization radars in particular; the new concept of applying general ambiguity function methods to the simultaneous transmission and reception of two orthogonally polarized signals is presented by Professor Dino Giuli and co-worker in **[VI-10]**. This latter new concept may open up new avenues of designing polarimetric Doppler radar systems for the analysis of target vibrational modes, etc., which certainly will become a subject of intense future R&D activities.

Whereas the polarimetric systems described during the workshop were mainly CW and rather narrow-band polarimetric radar systems, it is anticipated that we will be dealing with the description of wide-band (20% bandwidth), broad-band (50% bandwidth), and truly ultra-wide band (many octaves, e.g. 300 KHz to - 300 GHz desired non-carrier-frequency impulses) polarimetric (simultaneous orthogonal channel transmit-receive processor) systems during the forthcoming NATO-ARW-WPDR'93.

C.3.7 Polarimetric Synthetic Aperture Radar (POL-SAR) and Inverse SAR (POL-ISAR) Systems: Topic VII

Most recently, POLarimetric Synthetic-Aperture-Radar (POL-SAR) systems and its inverse configurations (POL-ISAR) have become available and thus allow one to deploy the novel concept of the Polarimetric Matched Image Filter (PMIF) which is based on purely polarimetric(scattering matrix) optimization procedures. The rapid development of these intriguing new target enhancement versus background clutter rejection methods is discussed and verified with the use of POL-SAR data sets recently made available by NASA-JPL.

At the time of our first NATO-ARW-IMEI'83, the near future availability of truly complete Polarimetric SAR systems was still considered a dream of the far-removed future. However, with the many spectacular advances made at CAL-TECH/JPL, Pasadena by Drs. Walter E. Brown, Jr., David Held and in particular by Dr. Fuk Li; at Loral (formerly Goodyear Aerospace Systems Corp.) Lichfield,AZ by Russell Blair, and Drs. Paul W. Goetz and Phil Murray; at ERIM, Ann Arbor by William E. Brown, Dale A. Ausherman, Roger J. Sullivan, Robert A. Shachman and Robert F. Rawson, such POL-SAR systems have now — within a short decade — become a "household item" in global terrestrial and planetary remote sensing. Thus, it is appropriate

to start with two papers of CAL/TECH/JPL, introducing here Dr. Jakob J. Van Zyl, who deserves high praise and credit for refocusing the CAL-TECH/JPL efforts onto the proper path [VII-1] by de-emphasizing the brute-force Mueller matrix data reduction procedures explained in [VII-2]. This set of two papers is followed by two papers of the ERIM POL-SAR image processing team, which under its team leader Dr. Ivan J. LaHaie also contributed most profoundly to POL-SAR "in vitro/in vito" scatter image analysis, where [VII-3] deals with statistical classification of POL-SAR images, [VII-4] with its applications to target characterization and discrimination, and [VII-5] with computer simulation of polarimetric radar and laser imagery. In VII-6, Krogager investigates various decomposition schemes of the Sinclair matrix with specific applications to high resolution radar target imaging. From the very inception of Polarimetric SAR systems design and implementation, the workshop director's laboratory effort was strongly focused on the complete utilization of polarization information dating back to 1974 in polarization-dependent microwave holographic image formation [72,73] and to 1978 in polarimetric microwave tomographic image formulation [43]. Especially, we were the first to draw attention to the span-invariant [74] and its use in achieving speckle reduction [75]. Whereas, in [VII-7] a well-done computer-animated image interpretation for POL-SAR parameters was contribed by Geaga unfortunately placing too much emphasis on "computer image cosmetics" instead of clearly establishing what complete polarimetric utilization in POL-SAR image analysis can truly achieve, this indeed is accomplished in the well-orchestrated post-workshop contribution of the workshop director and students [VII-8]. In [VII-8] various POL-SAR speckle reduction and discrimination optimizers are compared with those by others [76, 77], and the further advancements of all of these efforts need to be followed up carefully! The next paper by Hoogeboom [VII-9] surveys the efforts of the Dutch L-band POL-SAR design, implementation and operation; and, we refer here to the forthcoming joint NASA/ESA/ISAS event of POL-SAR Systems Calibration, DLR-Oberpfaffenhofen, rescheduled due to the Mid-East Petroleum crisis from 1991 January 26-28 to 1991 October 9-18, where other European (POL-SAR: DK) and Japanese (POL-SAR: ISAS) systems will be scrutinized on their pre/in-flight/post operational calibration capabilities. This section (VII) is then concluded with an innovative POL-ISAR target detection study by Profs. Andrew J. Blanchard and Adrian K. Fung and co-workers of the famed Wave Scattering Laboratory at the University of Texas at Arlington [VII-10]. All of these papers provided plenty fruits of thought for the activities of working discussion group W-D [IX-4] and also W-E [IX-5] and W-F [IX-6] as relates to the development of standards and calibration procedures.

C.3.8 Polarimetric Radar Meteorology and Oceanography: Topic VIII

Polarimetric radar systems implementation are especially well suited for the analysis of meteorologic and oceanographic scatter for which the term ($\nabla\varepsilon/\varepsilon$) shows marked local changes. Recent outstanding advances in these fields are highlighted. Various polarimetric doppler radar systems facilities are compared for illustrating the inherent inter/transdisciplinary complexities of these fields.

Two of the principle areas of application of polarimetric radar, scatterometry, SAR and ISAR systems are radar meteorology and wide-area ocean surface and coastal region air-borne and space surveillance. At the time of execution of this NATO-ARW-DIMRP'88, polarimetric radar meteorology

was much further advanced in comparison to POL-SAR wide-area ocean surveillance which, however, has caught up very rapidly in the meantime[78]. Based on the principle interests at that time of the prime institutional workshop supporter, the DLR at Oberpfaffenhofen, major and special emphasis during our workshop was placed on assessing the progress made in Polarimetric Radar Meteorology (also refer to **[O-4]**), starting off with the descriptions of systems performance, calibration and measurement capabilities of some of the very best test-bed instrumentation Polarimetric Doppler Radar Systems of the time: **DLR [VIII-1]**, CHILL **[VIII-2]**, DUT **[VIII-3]**, FIR **[VIII-4]**, NRC **[VIII-5]** with the RADC and RAT-SCAT systems already described in **[VI-1]** and **[VI-5]**.

A thorough up-to-date polarimetric radar assessment of our current understanding on the propagation through rain is presented by Dr. Anthony R. Holt in **[VIII-6]**. Here, we refer to the comparative analysis provided by Seliga and Humphries and Metcalf [79] and by Bringi and Hendry [80], respectively, on the history of radar meteorology and on the development of POL-DOP-RAD systems for radar meteorologic applications in the Western hemisphere as presented in [81], whereas, those accomplished - during the same period within the Soviet block - are succinctly summarized by Kanareikin et al, in the invited review **[O-4]**. The next two papers by Dr. Dusan S. Zrnic and colleagues **[VIII-7]** and by Prof. Viswanathan N. Bringi and students **[VIII-8]** are outstanding expositions on the utility of polarimetric Doppler radar measurements of weather radar and convective storms. The last two papers provide a simplified backscatter model of fluctuating distributed rain backscatter **[VIII-9]** by Agrawal and Boerner, and of rough sea surface scatter by Lande **[VIII-10]**. Much emphasis will be placed on multi-band POL-SAR (P/L/S/C/X/K/V/W) and UWB-POL-DOP-RAD analyses of sea-surface and also meteorologic scatter during the forthcoming third NATO-ARW-WPDR'93. Here, however, we emphasize that contrary to what was initially anticipated by some non-believers in POL-RAD/SAR applications [Atlas, 81], polarimetry will also play a major role in air/space-borne POL-SAR global terrestrial and planetary meteorologic and oceanographic remote sensing [82]. Authors and speakers of these topical papers **(VIII)** were truly most instrumental in guaranteeing the success of the working discussion group activities which is evident from the perusal of names of contributors of all of the resulting reports.

C.3.9 Final Reporting of Workshop Discussion Group Activities: Topic IX

The workshop discussion group activities are intended to provide recommendations for potential future research projects. The six basic topics (**W-A** to **W-F**) chosen define issues for which immediate answers are required. Details on the Workshop Discussion Group Topics and Activities are provided in the Background Section **[IX-0]**, summarized in the Concluding Remarks **[IX-7]**, and a preview on a resulting third NATO-ARW-WPDR'93 is given in **[IX-8]**. These reports (**[IX-1]** to **[IX-6]**), which are collected at the end of **Part Two**, provide an assessment of the progress made after execution of the first NATO-ARW-IMEI'83, and they present the integral status and the important future emphasis of these polarimetric radar techniques to electromagnetic sensing and imaging. We encourage the readers of these Proceedings to peruse first the final reports of the workshop discussion group activities of topical Section **IX**, before embarking into the critical assessment of individual papers presented in Topical Sections I to **VIII** within Parts One and Two of these Proceedings.

C.4 RELATION TO OTHER NATO ADVANCED STUDY INSTITUTES (ASI) AND ADVANCED RESEARCH WORKSHOPS (ARW)

Over the past decades, NATO-ASI/ARWs have provided a continuing forum for fundamental results and latest developments also in the topical fields of "Signal & Image Processing", "Pattern Recognition and Target Identification", "Non-destructive Material Testing and Non-Invasive Radiologic Diagnosis", "Inverse Problems and Profile Reconstruction", etc. Whereas, continual up-dates on all newly appearing NATO-ASI/ARW Proceedings are provided in the Quarterly NATO Newsletter of the NATO-SAD, Brussels and of the NATO Publications Coordination Office, here several recent ASIs and ARWs pertinent to this series of NATO-ARWs: (IMEI'83, DIMRP'88, WPDR' 93) are listed below with reference to the pertinent proceedings given in the List of References:

Physics and Engineering of Medical Imaging [83]
Industrial Robotic Vision [84]
Vision & Image Understanding [85]
Pictorial Data Analysis [86]
Diagnostic Imaging in Medicine [87]
Atmospheric Effects on Radar Target Identification and Imaging [88]
Surveillance of Environmental Pollution and Resources by Electromagnetic Waves [89]
Theoretical Methods for Determining the Interaction of Electromagnetic Waves with Structures [90]
Pattern Recognition Theory and Applications [91]
Remote Sensing Applications in Marine Science and Technology [92]
Optical Metrology [93]
The Application of Laser Light Scattering to the Study of Biological Motion [94]
Nonlinear Phenomena at Phase Transitions and Instabilities [95]
Image Sequence Processing and Dynamic Scene Analysis [96]
Aspects of Signal Processing with Emphasis on Underwater Acoustics [97]
New Directions in Signal Processing in Communications and Control [98]
EM Modelling & Measurements for Analysis & Synthesis Problems [99]
Signal Processing and Pattern Recognition in Non-destructive Evaluation of Materials [100]
Pattern Recognition and Signal Processing [101]
The Impact of Processing Techniques on Communications [102]
Fast Electrical and Optical Measurements [103]
Modern Topics in Microwave Propagation and Air-Sea Interaction [104]
ELF/VLF Radio Wave Propagation [105]
Pattern Recognition Theory and Applications [106]
Advanced Physical Oceanographic Numerical Modelling [107]
Large-Scale Transport Processes in Ocean and Atmospheres [108]
Remote Sensing Applications in Meteorology and Climatology [109]
Electromagnetic Coupling in the Polar Clefts and Caps [110]
Microwave Remote Sensing for Oceanographic and Marine Weather-Forecast Models [111]

In conclusion, this NATO Advanced Research Workshop has demonstrated both the basic unity of direct & inverse methods in radar polarimetry and the diversity of their applications to high resolution imaging and remote sensing. The Proceedings of this workshop represent, however, only one sampling of the development of this active new area of science and technology. Yet, these Proceedings will provide workers with sufficient

reference material and suggestions for new research topics to further their own continuing research development. The following rounding-off section gives a preview of related forthcoming events for which requests for active participation are invited, and the resulting proceedings should be studied carefully.

C.5: PREVIEW OF NEAR-FUTURE NATO AND OTHER INTERNATIONAL ARW ACTIVITIES FOR THE ADVANCEMENT OF DIRECT AND INVERSE METHODS IN ULTRA-WIDEBAND POLARIMETRIC RADAR TECHNOLOGY

The momentum gained during this rather time-consuming task of assembling these Proceedings of the NATO-ARW-DIMRP'88, and subsequent research workshops, retreats, and symposia during 1989 [53] and 1990 [54,59], resulted in the planning of Special Sessions on "Direct and Inverse Methods in Radar Polarimetry," and additional workshops for 1991, 1992, 1993 and already thereafter. Here, we alert the readers' attention to the forthcoming proceedings and research reports of some of these events.

1991

91-1 January 27-31: NASA/ESA/ISAS POL-SAR Calibration Workshop, DLR-Oberpfaffenhofen, FRG: Seven (7) sessions on POL-RAD/SAR Calibration (due to Mid-East Petroleum crisis cancelled and now rescheduled for 1991 October 9-18);

91-2 April 15-18: Seventh International Conference on Antennas & Propagation (ICAP), University of York, UK: Two (2) special sessions on radar polarimetry plus workshop (April 18-20);

91-3 May 20-24: MIKON'90, Ninth Polish Microwave Conference, Rydzyna-Poznan, Poland: Two (2) special sessions on Radar Polarimetry plus workshop (May 23-25); follow-up workshop/short-course lecture series considered either during week before or a week after, at the Technical University Dresden, FRG(0);

91-4 June 24-28: International IEEE/AP-S & URSI Radio Science Meeting, The University of Western Ontario, London, Ontario/Canada: Two (2) special sessions on radar polarimetry;

91-5 July 1-5: PIERS'91, MIT, Cambridge, MA: Various Special Sessions on "Direct and Inverse Methods in Radar Polarimetry" (W-M. Boerner);

91-6 September 17-20: Second Italian International Conference on Electromagnetics and Aerospace Applications, "ICEAA 91", Politechnico di Torino, Torino, Italia: Two (2) special sessions on fundamental polarimetric radar theory;

1992

92-1 March 20-22: Second French International Workshop on Radar Polarimetry: JIRP'92, IRESTE, University of Nantes, Nantes, France;

92-2 June 28-30: The International URSI-F Microwave Signatures Conference, Igls/Innsbruck, Austria (Dr. Wolfgang Keydel and Prof. H Rott, Co-directors): Several sessions on "Polarimetric Signatures, Techniques and Systems", (W-M. Boerner, W. Wiesbeck and J.J. van Zyl, convenors);

92-3 July 18-25: International IEEE/AP-S & URSI Radio Science Meeting, Hyatt Regency Hotel, Chicago, IL (W-M. Boerner, Vic Chair): Two (2) sessions on Radar Polarimetry;

92-4 August 11-13: Fourth (biennial) Asia-Pacific Microwave Conference-APMC'92, Adelaide Convention Centre, Adelaide, S.A., Australia. Two (2) Special Sessions on Radar Polarimetry - Theory/Metrology/Systems/Technology/Applications (W-M. Boerner and B. Haywood, conveners);

92-5 August 17-20: URSI International Commission-B, Electromagnetic Wave Workshop, Sidney Convention Center, Sidney, Australia: Two (2) sessions on Radar Polarimetry (W-M. Boerner, Convener);

92-6 September 1-18: First USSR Conference on "Polarimetric Radar Remote Sensing and Surveillance of the Terrestrial and Planetary Environments", USSR Academy of Sciences, Polar & Antarctic Division, Leningrad (92 Sept. 1-7) and Siberian Division, Lake Baikail, Ulan-Ude, Buryat Region, USSR (1992 Sept. 10-16) with A.B. Shupyatkij, A.I. Kozlov, N.B. Chimotdorzhiev and W-M. Boerner, conveners);

92-7 September 22-25: ISAP'92, Fifth International Japanese Symposium on Antennas and Propagation, University of Hakkaido, Sapporo, Japan: Two (2) sessions on Radar Polarimetry plus 3-day workshop (Y. Yamaguchi, M. Tanaka, H.J. Eom and W-M. Boerner).

1993

93-1 **September 19-25: NATO-ARW-WPDR'93: Wideband Polarimetric Doppler Radar Sensing, KuK Hotel Residenz, Bad Windsheim, FRG (although, currently proposed for 1991, September 18-24; we expect this NATO-ARW-WPDR to take place during 1993, September 19-25; and not during 1992, because of scheduling conflicts): W-M. Boerner, Director and Editor of Proceedings.**

In concluding this overview section, it should be observed that a strong international interaction program on "Radar Polarimetry: Theory-Metrology Instrumentation - Data Processing - Applications" is now developing as a result of the previous NATO-ARW- IMEI'83, our NATO-ARW-DIMRP'88, PIERS-'89, JIPR'90, and in particular, of the recent USA-USSR interactions, as summarized in the Technical Research Travel Interaction Reports [54-59].

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C.8 PREVIEW OF NATO-ARW-WPDR'93:

WIDEBAND POLARIMETRIC DOPPLER RADAR SENSING AND IMAGING for the instantaneous detection, ranging, imaging and identification of targets endangering and agents polluting our global planetary environment

C.8.1 Abstract:

In winding down the editing of the Proceedings manuscript, rather drawn out due to the integration of new important post-workshop contributions from both Eastern and Western radar polarimetrists, it was considered desirable due to the truly dramatic changes in world politics, the realignment of world powers, the resulting changing defense strategies and the emerging global environmental planetary crisis, to provide a post-summary of events leading to the preparation of a third NATO Advanced

Research Workshop in this series on "Wideband Polarimetric Doppler Radar Sensing and Imaging: NATO-ARW-WPDR' 93", to be staged again at the Kur-und-Kongress-Hotel Residenz, Bad Windsheim, Central Franconia, FRG during 1993, September 19-25.

C.8.2 **INTRODUCTION: Historical Socio-Scientific Post-Analysis of the NATO-ARW-IMEI'83 and NATO-ARW-DIMRP'88 on Direct & Inverse Methods in Electromagnetic Wideband, High Resolution Polarimetric Sensing and Imaging:**

In the past decade, during the preparation, execution and editing phases of these two workshops and their proceedings, we witnessed extra-ordinarily rapid technological advances, for example, in consumer goods production, hi-tech strike weapons development and in wide area military surveillance; however, often too much to the neglect of safeguarding our fragile planetary environment and cultural heritage. The first workshop took place at the height of the 'Two Superpowers Cold War' confrontation requiring the rapid development of 'hi-tech strike weapons' by utilizing complete electromagnetic vector wave target interrogation capabilities in high resolution radar sensing and imaging, which culminated in the advanced weaponry displayed in the NATO Reforger Exercises and in the Warsaw-Pact Counter-Maneuvers on opposite sides of the then existing Iron Curtain (FRG|GDR), precisely during the second workshop, as described in the DIRECTOR'S FOREWORD (prepared and completed in 1989 May!). For the first time, complete polarimetric high resolution sensor technology was tested, and our two workshops contributed strongly toward improving high resolution, wideband electromagnetic sensing and imaging for the rapid detection of highly camouflaged ('active RCS reduction') weapons systems, including surface-skimming cruise missiles, foliage covered armament and under-ground mines. However, the insanity of these maneuvers - measured on a global scale - invited our action and made many of us "crusaders for an end to the Cold War period". In pursuing this new challenge of finding a common denominator for more constructive co-existence by repeated counter-visits of remote sensing experts from the West (NATO, ANZAC, Liberated Asia, Pacific Rim) with those from the East (Soviet Communist Imperium, P.R. China & North Korea), another even more serious global problem disguised itself, namely, the flagrant neglect of environmental protection within Eastern countries far beyond the Great Lakes Environmental crisis of the early 1960's. In fact, increased world-wide traveling clearly demonstrates that our global planetary ecology - in East and West alike - is being subjected to increasing non-sustainable stress and, in spite of some piece-meal often all-too-emotional efforts, is further deterioriating rapidly. No immediate end to this global environmental planetary crisis is in sight due to the ever increasing global population explosion paired with the quest for ever new resources, the unnecessary misuse and squandering of scarce resources by the rich and a 'justified greed' by the poor, awakening third-world countries, etc. Especially with the recent disintegration — occurring soon after our second workshop of Sept. 1988 — of the Eastern European Socialist, the Soviet Imperialist and P.R. Chinese economies, it has become evident that the persistent environmental neglect of these regions resulted in the complete poisoning and almost irreversible pollution of its potable, industrial and recreational natural and artificial water resources. The heavily polluted lakes, rivers and ponds, in increasing numbers, are becoming "picture-book" examples of newly created breeding grounds of novel bacterial, fungal and viral diseases. For most of these newly created pests added to our global flora and fauna no immediate cures exist, and

its global distribution is facilitated by a rapid increase in inter/trans -continental (pleasure) travel of the masses. As a consequence, environmental neglect in one terrestrial region will affect progressively and - in future - immediately all other far-distant trans-continental regions and no longer excludes Arctica and Antarctica.

C.8.3 **The Emerging Global Environmental Planetary Crisis: The Causes for Changes in Global Defense Strategies:**

As many of us workshop participants witnessed during recent joint visits to "the East", is is not only the collapse of an obsolete consumer goods technology, of totally venerated industrial facilities, of the rigid ideologic system (Communist Party and KGB) which forced the USSR and its satellites to bring about the sudden mind-boggling changes in Global Defense Strategies! Certainly, the recognition by the USSR Academy of Sciences during the eighties of the severe seriousness of the environmental conditions most drastically impeding the future and current health and life of Soviet citizens, and its clear warnings to the Supreme Soviet of May 1989 has dictated the recent almost unreal removal of the iron curtain during the night of 1989 November 9/10, only one year after the Reforger Exercises at the height of the Cold War period which we participants of NATO-ARW-DIMRP'88 will never forget. In fact, the Supreme Soviet and its Army Chief of Staff were warned that however high, however deep the "iron curtains" be expanded, those cannot pose a barrier of containment to the "West-East/East-West" migration of environmental and sociological (drugs) pollutants, but that we are from here on into future dealing with a **"global environmental planetary crisis"** which must be combatted together and seen by all competing factions as our most important common defense issue, namely that of **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE"**.

Thus, as the awareness of the existence of a **'global environmental planetary crisis'** progresses, not only within the USA, the UK and all of NATO, but even within the USSR, a sudden **'HALT'** must be invoked in further increasing defense budgets to the detriment of safeguarding the environmental health of its people. Worldwide, we are hence coming to appreciate that we require **"Departments of Defense for the People from the** (i.e., all but not against one or other alien) **People"**, and that we - all together - must devise new ways and means of safeguarding and protecting our one and only precious and so fragile global planetary environment. It would be easy to add – since we met last - many more examples of the ongoing blatant attacks on our global planetary environment by irresponsible actions of the negligent rich (over-production of waste, export of contaminated waste for dumping in poor countries, and the most irresponsible universal suburban sprawl) and by the greedy poor (rain forest depletion) which are going to be forced on mankind with ever increasing intensity due to the uncontrolled population explosion, the major cause of global famines, environmental degradation and human misery.

Yet, another much more serious and truly dangerous terrorist attack on our global planetary environment was recently knowingly and willfully executed by igniting the 'oil-well torches' which constitutes the first true **MILITARY-ENVIRONMENTAL** connection on a global scale! It stands to reason that such acts of **"planned environmental piracy and terrorism"** could become a new **"environmental instrument of war and attack with long-lasting after-effects on culturally wealthy and environmentally healthy**

regions" by the desperate splinter nations and slowly assembling militant remnants of the rapidly disintegrating Soviet Socialist Empire in the near future-(predictable acts of global insanity!)

As a result of these recent events, we find that the "**chicken-versus-egg**" problem of **"global environmental planetary defense"** versus **"the restructuring and reprioritization of resulting military technology needs"** was and still is dictated by the period of global environmental neglect exercised with equal irresponsibilities by the East and the West since the advent of the Industrial Age and more recently with increasing intensity within the Socialist Soviet Empire. It has become a global overriding issue which, paired with the recent terrorist assaults on our global planetary environment, has forced the two superpowers, the USA-versus-USSR inclusive allies, to initiate collaboration by terminating the Cold War period, and has also taught the once staunch adversaries to become close allies (if not immediately, so definitely in the near future) in order to safeguard our global planetary environment which requires such combined, well coordinated global action. As a consequence of the cognizance of new and common **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE"** priorities, the build-up of wasteful, costly weapons arsenals and redundant military forces - as observed so vividly during the Reforger Exercises by all participants of NATO-ARW-DIMRP' 88 - can now be drastically reduced, resulting in the saving of valuable **"defense dollars"** and **"defense rubles"** simultaneously. Of course, these sudden, very decisive cuts in military spending are effecting the **"conventional military systems research & development as well as military weapons supply industry"** most drastically. In fact, our previous enemies may have to become our **"most sought for friends"** of the future in order to protect the entire terrestrial natural ecology and man-made cultures from further blatant environmental terrorist attacks and destruction.

C.8.4 **THE QUEST FOR NEW TECHNOLOGIES FOR THE STRENGTHENING OF "GLOBAL ENVIRONMENTAL PLANETARY DEFENSE":**

Fortunately, the observed need for the down-sizing of conventional and nuclear weapons R&D&E, maintenance, and supply is occurring precisely at a time when we require most urgently to address the issues of developing **"NEW ENVIRONMENTAL TECHNOLOGIES"** for safeguarding and defending our one and only global planetary environment:

THUS, the question to be raised is not how to find alternative markets for the excess capacity freed in defense brain-power, in defense R&D&E, and in the supply of defense technology; but - INVERSELY - it is the QUEST for identifying freed defense brain-power, vacant defense R&D&E and military garrisons, and the freed industrial facilities for developing the "NEW TECHNOLOGIES" for "GLOBAL ENVIRONMENTAL PLANETARY DEFENSE".

In fact, the closure of obsolete defense facilities, the consolidation of redundant and self-perpetuating R&D&E laboratories, and the realignment of the freed integral defense excess capacity — in the West and the East alike — is long overdue and the entire process must be sped up, and re-applied, i.e., literally thrown against combatting the identified **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE THREATS"**. The sudden seemingly apparent over-abundance of excess capacity of the military sector as a whole is hence occurring precisely at a time of great urgency and all we need to do is to refocus, to redirect, to retune, and to reestablish priorities

toward meeting the demands of environmental defense.

Development of NEW TECHNOLOGIES for "GLOBAL ENVIRONMENTAL PLANETARY DEFENSE": Certainly the relevant know-how in the pertinent technologies has been developed within our existing defense and space research centers and industries as relates to waste prevention and treatment (toxic and radioactive); reduction of air/water/soils pollution created by obsolete technologies; carbon-based transportation and energy generation; misguided agriculture (over-fertilization, over-use of toxic pesticides, etc.); site clean-up activities; the instantaneous detection of environmental terrorist attacks or accidental spills - from space, air/sea-borne or land-based sensor platforms; and the instantaneous isolation of such hazard zones from its immediate surroundings and the global environment from a planetary perspective. The capabilities of developing all of these technologies exist although with the caveat of being strictly applied to a military charter. But, technology is technology whether applied to military or civilian needs. Whereas, during the late 1960's to early 1980's, NASA's space technology transferred to consumer goods; **during the 1990's and beyond we hopefully may witness the transfer of non-sensitive military technology for solving environmental problems and for safeguarding our shared global planetary environment and cultural heritages.**

C.8.5 **International Realignment and Safeguarding of Sensitive Environmental Technology:**

The development of new technologies in **"Global Environmental Planetary Defense"** will become a major multi-billion dollar international business. Hitherto, the USSR, its former allies and most of the developing and third-world nations completely lack the **"know-how"** in this vital technology for future sustainability of life on this earth. Thus, it is to be anticipated that a very cut-throat **"environmental technologies warfare"** similar to that experienced by our "Western" car, electronics consumer goods and computer industry will emerge. This, in turn, will require preventive action. Although, there does not seem to exist another viable path but to combat this problem of **"Global Environmental Planetary Defense"** on an integral super-power approach, (i.e., hand-in-hand together with our near-past most dangerous adversary, the USSR), we must be on alert and protect our **"New Environmental Technology"** from a **"sell-out of our still existing edge"** to other aggressive nations, which could be tempted to misuse the gained knowledge and apply it inversely to developing even more sophisticated weapons for executing environmental acts of terror. Also, we need to develop immediately improved instantaneous discrimination methods of distinguishing between "friendly versus hostile fire (rallied casualties during recent Kuwait war)". It is precisely these issues which also must be tackled in conjunction with combatting **"Global Environmental Defense Threats"**. Definitely, we must walk the tight rope of addressing these newly emerging global versus nationalistic defense threats together with our recent adversaries, the USSR and its former East-Bloc Satellites, and all other mature nations.

In context with our two previous NATO-ARW's, the third workshop, planned for September 1993, thus, as a consequence of above considerations, invites full participation of experts from the past **"WEST"** versus **"EAST"** to meet together in Bad Windsheim, Germany, by addressing specific **"electromagnetic environmental sensing and imaging topics"** of **"GLOBAL**

ENVIRONMENTAL PLANETARY DEFENSE" which constitute some of the most urgent, unresolved problems of wide area terrestrial surface surveillance for the early mitigation of global threats.

C.8.6 **THE INSTANTANEOUS DETECTION, RANGING, SPECIFICATION AND IDENTIFICATION OF LOW OBSERVABLES AND OF POLLUTING AGENTS IN OUR TERRESTRIAL SURFACE ENVIRONMENT:**

One of the most pressing issues in **"Global Environmental Planetary Defense"** is **"Wide Area Global Environmental Surveillance"** with the ultimate goal of the **"instantaneous detection and/or prediction"** of major impeding environmental catastrophes which need not be created necessarily by man himself but by the ever-active deep-earth internal forces which affect our biosphere by such natural catastrophes like earth/sea-quakes with related tsunamies, by volcano-explosions and by major global weather changes also being induced by global earth-internal causes. Thus, we need to explore the specific "instantaneous disaster-prevention and mitigation" capabilities of the entire electromagnetic spectral regions in wide-area global environmental surveillance including the **lower ULF** (**below 10^{-3}Hz**: Earth-internal and coupled extra-terrestrial "gravitational sources" (with periods of days, weeks, months and years) which could trigger major global weather/climate changes; which if detected early enough, could allow for sufficient time for some wide area disaster mitigation); **the upper ULF and ELF** (10^{-3}**Hz - 10^{3}Hz**: earth/sea-quake and volcano activation precursor radiation; which if detected early enough, could lead to "well planned, deep earth disaster mitigation"); **ELF-LF** (**1KHz - 1MHz**: detection of otherwise "low observable objects" traversing the ionospheric fluid layer or skimming along the terrestrial surface which create acousto-electromagnetic, coupled terrestrial-ionospheric resonance phenomena); **HF-VHF** (**1MHz - 1GHz**: Ultra-wideband detection of low observables embedded in noisy background clutter, plus, passive wide area environmental security surveillance including penetration capabilities such as through foliage and into lossy soils); **M-Sub-MM** (**about 1GHz - 100GHz**: High Resolution target sensing and imaging in a wide area terrestrial boundary layer environment); **MM-IR** (**20GHz - 100THz**: Molecular spectroscopy and radiometric imaging); **IR/OPT/UV**(**10THz - 1QHz**: High resolution lidar sensing and imaging in atmospheric and oceanic environments (blue-green laser); further advancement of hitherto unresolved/undiscovered phenomena in polarimetric bionics and their bionic systems implementation into the development of improved **INSTANTANEOUS electromagnetic sensor systems**).

During the past decade the development of the required relevant High-Technology base was in principle pioneered in many pertinent disciplines such as in global multi-channel bulk data signal & image sensing, neural networking, parallel computer-processing, photonic mass data transfer and in spectral data fusion, which now allows us to approach the development of intelligent self-reliant automated sensors in

"HIGH RESOLUTION INSTANTANEOUS DETECTION, SENSING, SPECIFICATION, IMAGING AND IDENTIFICATION" of **"GLOBAL ENVIRONMENTAL PLANETARY THREATS"**,

so that "disaster mitigation" procedures may be enacted in time for regional and global disaster reduction and prevention. It is the objective of the forthcoming third workshop: **NATO-ARW-WPDR'93** to address

the **"Direct and Inverse Problems"** associated with **"Wideband Polarimetric Doppler Radar Sensing and Imaging within the pertinent spectral regions"** in this rapidly emerging new scientific discipline.

The outlay of the daily program and of the topical sessions will closely resemble that of the two previous workshops. However, during the forthcoming WPDR'93 workshop, main attention will be paid to an all-engulfing **'extra-wide-band'** approach together with various modes of spectral data fusion of separate **"wideband spectral sub-domain solutions"** which were loosely identified above. Specific details of the program will be provided by early 1993.

C.8.7 MEETING PLACE & DATE, ORGANIZATION & PROGRAM COMMITTEE, INTERNATIONAL EXPERT PARTICIPATION:

This third NATO-ARW is planned again with a five year delay so that the presentation of truly new advances is guaranteed; it is planned to be executed within the same, but further expanded Kur-und-Kongreß-Hotel Residenz, Bad Windsheim, Mittelfranken, because of its relative seclusion from the main European tourist arteries. The third week of September 19-25, was chosen again in anticipation of the pleasant and mild late summer/early fall weather of extended Main-Franken. In spite of the recent integration (1990) of the former German Democratic Republic in the Federal Republic of Germany, Franconia countinues to present the historic and cultural heart of the emerging Germany of the early 1990's with Mittelfranken (Central Franconia) and Oberfranken (Upper Franconia) establishing the historic links between Bavaria and Prussia through their pre-napoleonian margravedoms of Brandenburg-Ansbach and Brandenburg-Bayreuth, respectively. It is objective of the scientific-cultural program to highlight the changes that have occured since the waning of the Cold War in context with the theme of our third workshop. Thus, whereas during NATO-ARW-IMEI'83 scientific/cultural events were centered on Central Franconia (Nürnberg-Erlangen-Bamberg) with program-termination in Würzburg, the heart of Main-Franken mainly dealing with direct and inverse methods in electromagnetic imaging; and, during NATO-ARW-DIMRP'88 on the West-southern extension (Rothenburg-Dinkelsbühl-Oberkochen-Ulm) with program termination at DLR-Oberpfaffenhofen near München, the capital of Bavaria with prime emphasis on high-resolution polarimetric sensing and imaging; the scientific-cultural events of the third NATO-ARW-WPDR'93, are directed toward the East-northern cultural extension of Central Franconia culminating in Berlin-Brandenburg recently chosen to become the new capital of the 'United Germany' after the "iron wall" was torn down (1989) and removed (1990). The Wednesday ('93 Sept. 22) scientific-cultural event of WPDR'93 includes planned visits to Bayreuth (FESTSPIELHAUS of Richard Wagner, the baroque opera and the Erimitage), together with a scientific tour of the deep-earth drilling project (10-12 km deep) at near-by Windisch-Eschenbach for exploring deep-earth environmental forces. Separately, a visit of the Markgrafenschloss Ansbach is planned in order to highlight the existing 'Prussia-Franconia-Bavaria connection', before leaving by Special busses for Berlin, on late Friday evening, after the banquet. We plan to terminate the NATO-ARW-WPDR'93 at one of the new additions to the German Aerospace Research Establishments, the DLR-Research & Development Center in Remote Sensing of Planetary Hydrospheres, Crusts and of Interior Planetary Chemistry/Geophysics at the DLR-Forschungszentrum Berlin-Adlershof in former East Berlin (the former GDR, Academy of Sciences, Cosmos Research Institute). Whereas, the

scientific visit to the KTB (Kontinentale Tiefbohrung in der Oberpfalz) Windisch-Eschenbach is programmed to clarify subtleties of lower ULF electromagnetic sounding of deep earth forces, the visit to Berlin-Adlershof at the Eastern outskirts of the new capital of eastward-extended FRG, is most essentially directed toward exploring the development of intelligent sensors in the upper spectral regions for the instantaneous detection, specification and identification of natural and 'cultural' (induced by living beings) environmental phenomena and hazards via electromagnetic remote sensing from space. Both projects constitute international East-West research interactive programs, supported not only by 'BMFT/BRD' (the - Federal German Ministry of Research & Technology) but also by all other NATO-member countries, Japan, Eastern European countries and by the USSR Academy of Sciences including the BICER (Baikal International Center of Ecological Research), Deep Drilling & Deep Lake Sounding projects.

In light of the recent East-West rapproachment and of the truly international character of research in "global environmental planetary defense", the organization and program committees have been slightly enlarged to include expertise from the Asia-Pacific Rim and the former Soviet Socialist Empire which also is reflected in the list of invited international expert participants as will be disclosed in early 1993. Participation in NATO-ARW-WPDR'93 is mainly by expert invitation and limited to about eighty selected active contributors plus a few observers.

In conclusion, this third NATO-ARW-WPDR'93, in continuation of NATO-ARW-DIMRP'88 and of NATO-ARW-IMEI'83, is to promote the advancement of a rapidly emerging "Global Environmental & Cultural Planetary Defense" science and technology.

4-D: LIST OF PLANNING/ORGANIZATION COMMITTEE, EDITING COMMITTEE, PUBLISHER/ PARTICIPANTS/CONTRIBUTORS AND SPONSORS

D.1: Supporting Organizations

Similar to the planning, organization, and execution of the first ARW of 1983, NATO-ARW-IMEI'83, during the second NATO-ARW-DIMRP'88, we have chosen the ideally suited conference facilities of the KuK Hotel Residenz at Bad Windsheim. Located close to Erlangen and with the recent opening of the new section of the Interstate/Autobahn A7 (Würzburg-Ulm), the travel time from Oberpfaffenhofen to Bad Windsheim was reduced from four to two hours. Therefore, the choice of the main organizing institutions remained the same, with Prof. Wolfgang-M. Boerner (UIC), Dr. Wolfgang Keydel (DFVLR), and Prof. Dr.-Ing. Hans Brand (UEN), the main co-directors; who were assisted by senior staff of the organizations: Mr. Richard W. Foster, Mrs. Julie A. Furlong, Ms. Mirian R. Mailey, Prof. Hyo J. Eom and Dr. Yoshio Yamaguchi (UIC); Dr. Martin Vogel, Dr. Ernst Lüneburg, and Herr Reiner Weppner (DFVLR); Dr. Gerd Schaller and Frau Monika Kuehl, (UEN). In addition, several non-FRG co-directors, highly experienced, in particular, with the workshops were added at a later time.

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D.2.1: Coordinators of Scientific/Cultural Tours

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Dr.-Ing. Siegfried Osterrieder	Dr. Gerhard Boucke, TST
Dr.-Ing. Gerd Schaller, UEN	Prof. Wolfgang-M. Boerner

D.2.2: Hostesses of the Spouses/Cultural Programmes

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Mrs. Jutta Brockhoff, KuK	Mrs. Anita Zierlein, Tour. Guide

D.2.3: Planning and Resources Management

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Dr. Wolfgang Keydel	Mrs. Monika Kuehl	Mr Richard W. Foster

D.2.4: Workshop Program Proceedings Development and Preparation

Mr. Richard W. Foster, UIC	Ms. Deborah A. Foster, UIC
Mrs. Julie A. Furlong, UIC	Ms. Mirian R. Mailey, UIC

D.3: Sponsors

The main sponsor of our NATO-ARW-DIMRP'88, the NATO Scientific and Environmental Affairs Division, provided the original grant.

(1a) SA. 5-2-04 (ARW 923/86)620(86)CS: ORIGINAL REQUESTS APPROVED

NATO Advanced Research Workshop
Direct & Inverse Methods in Radar Polarimetry
Bad Windsheim, FRG, 1988 Sept. 18-24
(Original Date: 87 May 24-30)

1987 May 18 :	BF	280,000.00	
1987 August 31:	BF	560,000.00	$1\$_{US} \triangleq$ 37,845 BEF
1989 March 07 :	BF	230,000.00	
	BF	50,000.00	
Sub-total Received	BF	1,120,000.00	$29,594.00

(1b) SA. 5-2-04 (ARW923/86)620(86)CS: Post-Workshop Request for Production of Proceedings Manuscript & Printing

1991 August 30:	BF	300,000.00	(Manuscript Preparation)
1991 August 30:	BF	281,000.00	(Printing of Coloured Pages)
1991 October 28:	BF	196,000.00	(Surcharge for Printing Col. Pages)
	BF	777,000.00	*pending $20,532.00*

(1c) Request for 150 Free Proceedings (Pts 1 & 2) Copies

1991 August 30:	BF 1,362,420.00	$36,000.00*
($240 per Volume of Proceedings with 2 parts)		
Sub-Total (Pending):		*pending **$56,532.00***

(2) DLR-Oberpfaffenhofen, FRG
Provision of staff-support, institutional vehicles, telephone/telex, fax, mail, accounting, etc. = approx. $12,000.00

(3) UIC-EECS/CSL, Chicago, USA
Provision of staff-support, preparation of application, announcements, execution, editing, mailing, telephone/telefax, telex, travel, etc. (excluding salaries):

Pre-Workshop Expenditures	$10,000.00
Workshop Expenditures	$ 8,000.00
Post-Workshop Expenditures	$24,000.00
Sub-total:	$42,000.00

(covered by University of Illinois Foundation, Senior Scholar Award)

(4) UEN-HF, Erlangen, FRG
Provision of staff-support, execution of workshop, typing, accounting: approx. $3,000.00

(5) Scientific Tour Programs (Industries)
Carl Zeiss, Oberkochen: $3,000.00
AEG-TST, Ulm: $3,000.00

Sub-Total: $92,594.00

(6) Participants: $30,000.00 (toward payment of total costs, for lodging and food during workshop, but excluding travel)

Sub-Total: $122,594.00

(7) ARO-Proceedings Publications Contract
Preparation of Final manuscript (including release of overhead by UIC): $16,791.00 (approx. $16,800.00)

(8) Approximate Total:

Received: $: 139,394.00
Pending: $: 56,532.00*

D.4: List of Registered Participants (Workshop)
(attached)

D.5: Post-Workshop Contributors
(included in List of Proceedings Contributors)

D.6: List of Proceedings Contributors
(address list attached)
authors index

D.7: Official Language: ENGLISH
Note, throughout all phases of the Workshop the one and only language used during formal discussions was ENGLISH. However, participants were encouraged to utilize their multilingual capabilities among participants from 18 different countries.

D.8: Conference Facilities

Although we all were already highly satisfied with the outstanding conference facilities of the

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during the NATO-ARW-IMEI'83 of 1983 Sept. 18-24, the facilities have since been greatly expanded and perfected so that 180 scientific participants can easily be housed under one roof in an ideal spa park environment which has greatly benefitted our meeting. (see attached)

D.9: Conference Record

NATO-ASI, Series S, Mathematical and Physical Sciences, Vol 350 (Pts 1&2)
D. Reidel Publ. Co./Kluwer Academic Publisher
Estimated Publication Date: Fall, (December) 1991, Distribution: January 1992

ISBN-0-7923-1498-0 (Sel)
ISBN-0-7923-1496-4 (Vol. 1)
ISBN-0-7923-1497-2 (Vol. 2)

Content: 86 Technical Papers (including monographs, reviews, etc.) and 8 Discussion Group Reports: approximately 1936 pages when printed.
Estimated Price per Two-Part Proceedings: $200.00 - $240.00
Total number to be printed: 3,000
Number of copies to be provided in return of support will depend on amount of support and would not exceed 3 copies (for ARO).

5. **REPORT ON INNOVATIONS: THE RESTRUCTURING OF INTERNATIONAL INTERACTIONS AND THE MILITARY - EVNIRONMENTAL CONNECTION**
- CONCEPTS, IDEAS, VIEWS, OPINIONS AND/OR FINDINGS CONTAINED IN THIS SECTION ARE THOSE OF THE AUTHOR, DR. WOLFGANG-MARTIN BOERNER, AND SHOULD NOT BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION, POLICY, OR DECISION. HOWEVER, IT WAS DEEMED APPROPRIATE TO INCLUDE THIS MATERIAL IN THIS REPORT, BECAUSE THE CONCEPTS HERE DEVELOPED ORIGINATED - TO A MAJOR EXTENT - DURING THE PREPARATION AND EXECUTION OF THE WORK-SHOP AND THE POSTWORKSHOP EAST-WEST ENGAGEMENTS RESULTING THERE-FROM.

5.0 **THE INVENTION:** (1) The concept of **'GLOBAL ENVIRONMENTAL PLANETARY DE-FENSE'**; (2) The Utilization of Complete Wideband Electromagnetic Spectral (10^{-6} Hz - 10^{-5} Hz) Wide-Area Surveillance for **THE INSTANTANEOUS SENSING, DETECTION, RANGING SPECIFICATION OF HOSTILE TARGETS AND HAZARDOUS AGENTS POLLUTING OUR ONE AND ONLY TERRESTRIAL AND PLANETARY ENVIRONMENTS:**

W-M. Boerner and J.B. Cole, FROM MILITARY TO PLANETARY ENVIRONMENTAL DEFENSE: The Challenge of the Next Century, and a Viable New Role of the US Military in an "Environmental Planetary Defense Initiative" on a Global Scale, in B. Pope, ed., Proceedings of the 'Defense Industry and the Environmental Agenda - Symposium 91, Oct. 9 - 10, Tyson Corner, Vienna, VA/USA, National Security Industrial Association, NSIA-Press, Washington, D.C., pp x00-X10!, Dec. 1991. (see Appendix 7.7)

6. BIBLIOGRAPHY

6.1 MAJOR PUBLICATIONS OF WORKSHOP DIRECTOR DURING THE PLANNING & EXECUTION OF TH WORKSHOP AND DURING POST-WORKSHOP PREPARATION OF MANUSCRIPT

6.1.1 Books and Monographs (1985-1992):

B-1 **W-M. Boerner et al., (eds.) Inverse Methods in Electromagnetic Imaging, Parts 1 & 2, NATO ASI Series C: Mathematical & Physical Sciences, Vol. 143, D. Reidel Publishing Co., Dordrecht/Boston/ Lancaster, January 1985.**

B-2 W.M. Boerner, F.A. Molinet, H. Überall, SOC-MOTH(NATO), Advanced Research Short Course, Vector Inverse Methods in Radar Target/ Clutter Imaging, Co-Editor, Proceedings, ARSC, Ecole Superieur d' Electricite, Gif-sur-Yvette, France, 1986, Sept 1-4, Springer Verlag, Heidelberg, 1989, total pages: 428.

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B-4 L.W. Root, B.L. Matkin and W-M. Boerner, (eds.) Proceedings of the Third Polarimetric Radar Technology Symposium, 1988 August 12-16, Rocket Auditorium, US Army Missile Laboratory, Redstone Arsenal, AL, GACIAC, IIT-RI, Chicago, IL, August 1990.

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(w-42) Y. Yamaguchi, M. Mochida, M. Sengoku, T. Abe, W-M. Boerner, "Effects of View Angle in Vector Diffraction Tomography", Proceedings, Third Asia-Pacific Microwave Conference, Tokyo, 1990 Sept. 18-21, Paper No. 40-3, pp. 929-932.

(w-43) W-M. Boerner, H.J. Eom, and Y. Yamaguchi, "Conditions for the physical realizability of Mueller and Stokes Reflection matrices and their implications on the calibration of conerent polarimetric radar and SAR systems, CEOS-SAR-CAL Workshop, DLR, Oberpfaffenhofen, FRG, 1991 Jan 28-30 (due to Mid-East crisis, cancelled and rescheduled for 1991 Oct. 9-14), pp ___ - ____ (Proceedings), Dec. 1991.

(w-44) E.J. Eom, Y. Yamaguchi and W-M. Boerner, "Calibration considerations for polarimetric radar and POL-SAR systems due to rough surface incoherent backscattering of spherical waves", CEOS-SAR- CAL Workshop, DLR, Oberpfaffenhofen, FRG, 1991 Jan 28-30 (due to Mid-East crisis, cancelled and rescheduled for 1991 Oct. 9-14), pp ____ - (Proceedings) Dec. 1991.

(w-45) Y. Yamaguchi, W-M. Boerner, and H.J. Eom, "Calibration of polarimetric FM-CW radars and its implications on that of POL-SAR systems", CEOS-SAR-CAL Workshop, DLR, Oberpfaffenhofen, FRG, 1991 Jan 28-30 (due to Mid-East crisis, cancelled and rescheduled for 1991 Oct. 9-14), pp _____ - ____

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(w-46) W-M. Boerner, "Comparison of Optimization Procedures for the 2x2 Sinclair and the 4x4 Mueller Matrices in Coherent Radar Polarimetry and its Applications to Radar Target vs. Background Clutter Discrimination", N'tl Telesystems Conference, NTC'91, March 26-27, Atlanta, GA, paper 3.4, Proc., pp 89-98, 1991 March.

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(w-51) W-M. Boerner, (INVITED SESSION OPENING PAPER for Session: Polarimetric Inverse Scattering Problem), "The Polarization Correction of the Bistatic Formulation of Kennaugh's Physical Optics Scatterer Transient Romp Response Identity: Application to Polarimetric Radar Target Modeling"; MIKON'91, May 20-24, Rydzyna Castle, Poland, Proc., Vol. 1, pp. 289-293, 1991.

(w-52) W-M. Boerner, "Polarimetric Radar Theory - An Overview", Int'l Conference on Electromagnetics in Aerospace Applications (ICEAA'91), Torino, Italy, 1991 Sept 17-20, Session PR-I, Paper No. A-1, Proc., pp. 273-289, Sept. 1991.

(w-53) W-L. Yan, A-Q. Xi, W-M. Boerner, "Optimization Procedures for Sinclair and Mueller Matrices", Int'l Conference on Electromagnetics in Aerospace Applications (ICEAA'91), Torino, Italy, 1991 Sept 17-20, Session PR-I, Paper No. A-4, Proc., pp. 209-307, Sept. 1991.

(w-54) A. Schatzberg, W-M. Boerner, "The Importance of Polarimetry in Time-Domain Inverse Scattering - Theory and Applications", Int'l Conference on Electromagnetics in Aerospace Applications (ICEAA'91), Torino, Italy, 1991 Sept 17-20, Session PR-I, Paper No. B-6, Proc., pp. 315-317, Sept. 1991.

(w-55) Y. Yamaguchi, M. Mitsumoto, M. Sengoku, T. Abe, W-M. Boerner, "Polarimetric and Synthetic Aperture FM-CW Radar", Int'l Conference on Electromagnetics in Aerospace Applications (ICEAA'91), Torino, Italy,

1991 Sept 17-20, Session PR-II, Paper No. C-11, Proc., pp. 335-344, Sept. 1991.

(w-56) Y. Yamaguchi, H.J. Eom, W-M .Boerner, "Adaptive Communications Polarimetry", Int'l Conference on Electromagnetics in Aerospace Applications (ICEAA'91), Torino, Italy, 1991 Sept 17-20, Session PR-II, Paper No. D-16, Proc, pp. 363-368, Sept. 1991.

(w-57) W-M. Boerner, J.Y. Dea, W. Van Bise, E. Raushcer, "Sensing of ELF Signatures Arising from Vehicle Disturbances of the Ionosphere", Proc. 49th AGARD-EPP Symposium on Remote Sensing of the Propagation Environment, Çesme-Izmir, Turkey, 1991 Sept 30-Oct 04, Paper No. 19, pp. (11), Dec. 1991.

(w-58) W-M. Boerner, J.Y. Dea, C.I. Richman, "Sensing of Seismo-Electromagnetic Earth/Sea-Quake Precursor Radiation Signatures Along Southern Californian Fault Zones: Evidence of Long Distance Precursor ULF Signals Sensed Before a Moderate Southern California Earthquake Episode", Proc. 49th AGARD-EPP Symposium on Remote Sensing of the Propagation Environment, Çesme-Izmir, Turkey, 1991 Sept. 30 - Oct. 04, Paper No. 20, pp. (8), Dec. 1991.

(w-59) W-M. Boerner, W-L. Yan, A-Q. Xi, Y. Yamaguchi, "Basic Equations of Radar Polarimetry and Its Solutions for the Sensing of Propagation Path Polarizations State Changes", Proc. 49th AGARD-EPP Symposium on Remote Sensing of the Propagation Environment, Çesme-Izmir, Turkey, 1991 Sept. 30 - Oct. 04, Paper No. 35, pp. (9), Dec. 1991.

(w-60) W-M. Boerner, H.J. Eom, Y. Yamaguchi, "Adaptive Communications Polarimetry: Sensing of Propagation Path Changes and Adapting to Optimal Performance in Cellular Communications", Proc. 49th AGARD-EPP Symposium on Remote Sensing of the Propagation Environment, Çesme-Izmir, Turkey, 1991 Sept. 30 - Oct. 04, Paper No. 36, pp. (6), Dec. 1991.

(w-61) W-M. Boerner, J.B. Cole, (invited), FROM MILITARY TO PLANETARY ENVIRONMENTAL DEFENSE: The Challenge of the Next Century, and a Viable New Role of the US Military in an "ENVIRONMENTAL PLANETARY DEFENSE INITIATIVE" on a Global Scale, Proc. NSIA-DEFENSE INDUSTRY AND THE ENVIRONMENTAL AGENDA-SYMPOSIUM'91, B. Pope, ed. Oct. 9-10, Sheraton Premier Hotel at Tyson Corner, Vienna, VA (10 printed pages) Nov. 1991.

(w-62) W-M. Boerner, M. Walther and A. Segal, The concept of the Polarimetric Matched Signal and Image Filters: Application to Radar Target Versus Clutter Optimal Discrimination in Microwave Imaging and Sensing, Proceedings EARSEL, Workshop on Microwave Imaging & Sensing, Alpbach, Austria, 1991 Dec. 2-4; and JRC, Ispra, Italia, 1991 Dec. 5-6, Proc. (18 pages) Feb. 1992.

(w-63) W-M. Boerner, C-L. Liu and X. Zhang, Comparing of the Optimization Procedure for the 2x2 Sinclair and the 4x4 Mueller Matrix in Coherent Polarimetry and Its Application to Radar Target Versus Background Clutter Discrimination in Microwave Sensing & Imaging, Proc. EARSEL, Workshop on Microwave Imaging & Sensing, Alpbach, Austria, 1991 Dec. 2-4; and JRC, Ispra, Italia, 1991 Dec. 5-6, Proc. (24 pages), Feb. 1992.

6.1.4. Technical Reports (R-1 to R-10)

R-1 W-M. Boerner, "Vector Inverse Scattering Methods in Dual Polarization Radar Analysis", Annual Report for FY'88 (1988 Oct. 01 - to - 1989 Sept. 30), Office of Naval Research, Electronics & Applied Technology Division, Contract No. N00014-80-C-0773, 1988 November 15 (31 pages).

R-2 W-M. Boerner, Y. Yamaguchi and H.J. Eom, "Theoretical Backscatter Model for Snow: Microwave and Multimeterwave Remote Sensing of Snow and Ice Fields for the Detection of Low-RCS Targets in Severe Background Clutter", Interim Report (period 1988 November 21 to 1989 May 31), Battelle STAS 1178, Contract No DAAL 03-86-D-0001, US Army Missile Command, AMSMI-RD-AS-RF, 1990 July 15.

R-3 W-M. Boerner, Y. Yamaguchi and H.J. Eom, "Recent Advances in Radar Polarimetry in Japan and the FAR EAST: Applications to Polarimetric Radar Meteorology and Polarimetric Radar Remote Sensing of Snow and Ice Fields in Japan", Bulletin of the Office of Naval Research, Far East Scientific Liaison Division, Roppongi, Tokyo, Japan Vol., 1990 June.

R-4 W-M. Boerner, "Preparation of Proceedings Manuscript for NATO-ARW-DIMRP' 88 ARO Proposal No. 26773-GS, DAAL-03-89-K-0075", (period: 1989 January 01 - to - June 31, and 1989 July 01 - to - December 31).

R-5 W-M. Boerner, "Basic Polarimetric Signal/Image Processing Studies", Interim Progress Report (1989 June 25-Dec 31, Army Research Office, Electronics & Geosciences Div., Contract No. DAAL-03-89-K-9116), 1990 January 25 (32 pages).

R-6 W-M. Boerner, H.J. Eom, Y-K. Dhiantravan, Y. Yamaguchi, "Theoretical backscatter models for snow", Final Report, Battelle Momeorial, Del, Order, No. 1178 (Scientific Service Program), Contract No. DAAL-03-86-D-0001, US Army, MILAB, Advanced Sciences Lab, 1990 Oct. 01.

R-7 W-M. Boerner, "Vector Inverse Scattering Methods and Vector Signal/Image Processing in Dual Polarization Radar Analysis", Annual Report for FY 89 (1989 Oct 01 - 1990 Oct. 31), Office of Naval Research, Electronics & Applied Research and Technology Divisions, Contract No N00014-90-J-1405, 1990 Oct 31, (38 pages)

R-8 W-M. Boerner, "Preparation of Proceedings Manuscript for NATO-ARW-DIMRP' 88, ARO Proposal No. 26773-GS, DAAl-03-89-K-0075 (period 1990 July 01-to-December 31), 1991 January 31.

R-9 W-M. Boerner, "Final Report, Vector Inverse Scattering Methods and Vector Signal/Inverse Processing in Dual Polarization Radar Analysis", FINAL REPORT, Office of Naval Research, Electronics & Applied Research and Technology Divisions, Contract No. N00014- 90-J-1405, 1991 January 31.

R-10 W-M. Boerner, "Planning Report for 1991 US NAVY-ASEE-SFRP engagement of W-M. Boerner with US NAVY, NOSC, NWC, PMTC, NRL/ NOARL", 1991 June 09 - to - August 16 (1991 January 10).

R-11 W-M. Boerner, ed., Report on the "Establishment of a 'NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH' within the Historic District of FT. SHERIDAN, Lake County, Illinois, The Fort Sheridan Commission, Committee on

Education & Research, 1991 May 5.

R-12 W-M. Boerner, "Basic Polarimetric Signal/Image Processing Studies", Interim Progress Report (1991 January 31 - to - June 30), Army Research Office, Electronics & Geosciences Div., Contract No. DAAL-03-89-K-9116, 1991 August 30.

R-13 **W-M. Boerner, FINAL REPORT, Preparation of Proceedings Manuscript for NATO-ARW-DIMRP'88, ARO Proposal No. 26773-GS, DAAL-03-89-K-0075 (period 1989 Jan. 01 - 1991 Aug. 30), 1991 August 30 - T H I S R E P O R T -**

R-14 W-M. Boerner, "Vector Inverse Scattering Methods and Vector Signal/Image Processing in Dual Polarization Radar Analysis", Annual Report for FY91 (1990 Nov. 01 - 1991 Oct. 31), Office of Naval Research, Electronics & Applied Research and Technology Divisions, Contract No. N00014-90-J-1405, 1991 October 31.

R-15 W-M. Boerner, FINAL REPORT for 1991 US NAVY-ASEE-SFRP Engagement with US Navy Systems Centers: NOSC, NWC, PMTC, NADC, NSWC, NCSC and NRL/NOARL (1991 June 04 - to - August 16), **A PROPOSAL FOR THE ESTABLISHMENT OF A NETWORK OF "LOW-FREQUENCY (ULF/ELF/VLF) ELECTROMAGNETIC SIGNATURES RECORDING STATIONS WITHIN US NAVAL RESEARCH & TETS FACILITIES OF SOUTHERN CALIFORNIA (NOSC, NWC, PMTC, NCEL, NPGS) WITH MAIN SIGNATURES OBSERVATORY AT NOSC, POINT LOMA SEASIDE, SAN DIEGO, CA"**, 1991 November 15.

6.1.5 Overseas Travel Reports (T-1 to T-12: attached to orginal only)

T-1 **W-M. Boerner, International Travel Report on the 1989 May 13 to May 26 USSR Travel, Invitation by USSR Academy of Sciences and Alexander S. Popov Society for the Promotion of Research Interaction on "The Advancement of Inverse Methods in High Resolution Polarimetric Radar Imaging and its Applications to Hostile Object Discrimination Against/And the Remote Sensing of Terrestrial and Planetary Environments"**, UIC-EECS/CL Report No. 89-05-13 (prepared for the US Navy, Office of Naval Intelligence), 1990 July 15 (7 pages plus extensive back-up sub-reports on file).

T-2 **W-M. Boerner, International Travel Report on 1989, August 17 - to - September 13, Japan Travel of W-M. & V.W. Boerner:** The Participation as Invited Guest: "in the 1989 ISAP, Tokyo Toshi Center, 89 Aug. 22-25; (iii) the 1989 EMC Nagoya Int'l Congress Center, 89 September 07-10; and for the "Advancement of Inverse Methods in High Resolution Polarimetric Radar & Radiometer Imaging; and (iv) the Annual Forum on the "Establishment of Int'l Science & Technology plus Environmental Preservation Parks, Cities, Metropolis and Megalopoles in Japan, UIC-EECS/CL Department No. 89 08-17 (12 pages plus extensive sub-reports and material on file: **prepared for the Office of Naval Research FAR- EAST Scientific Liaison Division, Roppongi, Tokyo, Japan).**

Plus: Research Travel Report on "Research in Direct and Inverse Methods in Radar Polarimetry - Applications to: (i) ELF/VLF direction finding and detection of geo-electromagnetic earthquake/volcano tremor precursor radiation; (ii) the remote sensing of the environment with Dual Polarization Doppler and POL- SAR systems; (iii) the development of EO fibre-optical real-time polarimetric multi-channel signal/image processors; (iv) the development of a joint international program on

microwave remote sensing in meteorology & oceanography: A report on recent visits as a US Senior Scientist Fellow awardee by the Japan Society for the Promotion of Science (JSPS) during 1986, 1988, and 1989" (1989 Sept. 25/expanded: 1990 Jan. 15).

T-3 W-M. Boerner, Y. Yamaguchi and H.J. Eom, "Recent Advances in Radar Polarimetry in Japan and the FAREAST: Applications to Polarimetric Radar Meteorology and Polarimetric Radar Remote Sensing of Snow and Ice Fields in Japan", Bulletin of the Office of Naval Research, Far East Scientific Liaison Division, Roppongi, Tokyo, Japan Vol., 1990, June (prepared 1990 Jan 15).

T-4 W-M. Boerner, International Travel Report on 1989 November FRG-(USSR)-JAP TRAVEL for: (a) The Advancement of Inverse Methods in High Resolution Polarimetric Radar Imaging and its Application to Target Discrimination against/and Remote Sensing of the Terrestrial Boundary Layer; and (b) The Establishment of International Science & Technology plus Environmental Parks, Cities, Metropoles and Megalopoles: (5 pages plus extensive sub-reports, video and book back-up material) prepared for the University of Illinois Office of International Affairs, Chicago, IL UIC-EECS/ CL Report No. 1989 011-03, (1989 November 25).

T-5 W-M. Boerner, International Travel Report on 1990 March 17 to 25, NATO-Europe Research Travel of W-M. Boerner for Advancing Interaction on "Wideband Polarimetric Doppler Radar Target Detection, Imaging & Identification and Environmental Sensing" at ONR-European Branch Office/London, UK; CELAR, Bruz, FR; IRESTE, Université de Nantes, La Chantrerie/Nantes, FR; ONERA/ Paris, FR; NATO-SAD/Brussels, BEL; NATO-PCO/Overijse, BEL; NATO- ARW-DIMRP'88 Proc. Publisher: D. Reidel Publ. Co./Dordrecht, NL; DUT/ Delft, NL; SHAPE-TC/Scheveningen, NL; Keukenhof/ Lisse, NL; and UNESCO/Den Haag, NL (18 pages).

Plus: Research Travel Report (12 pages) on "Wideband Polarimetric Doppler Radar Sensing & Imaging", prepared for publication in the ONR-ESN-Information Bulletin, ONR-European Branch Office, Edison House, 223 Old Marylebone Rd., London NWI-5th, England, UK (ONR, Box 29, FPO New York/USA 09510-0700) 1990 March 30.

T-6 W-M. Boerner, Report on 1990 May 5 to May 18, Visit of Six Polarimetric Radar Experts from the USSR (Technical Report & Budget, including summaries of events by D.S. Zrnic and J.R. Huynen), 1990 May 21.

T-7 W-M. Boerner, Final Report, US Navy ASEE-SFRP Distinguished Senior Professor Engagement with the Naval Ocean Systems Center, San Diego, CA, 1990 June 03 - August 10 on "Ultrawideband Polarimetric Impulsive Radar Large Area Ocean Surveillance Sensing and Imaging"

T-8 W-M. Boerner, Final Report on a Cultural & Research Interaction Travel to the Buryat Autonomous Soviet Republic in South-Eastern Siberia, USSR of 1990 August 17 to September 04, entitled Joint US-USSR Global Environmental Preservation Interaction Program: "Save The Terrestrial Great Lakes: Baikal/Michigan Lakes Environmental Threatre Festival," Ulan Ude, and Lake Baikal, Buryata, South-Eastern Siberia, USSR 1990 August 20 - to - September 03.

T-9 W-M. Boerner, Final Research Interaction Report on 1990 Sept. 07-to-27

Japan Travel, entitled "USA-Japan Research Interaction on Exchange of Advanced Research in Information and Sensing Sciences on Radar Polarimetry and Diffraction Tomography" and "Seismo-electromagnetology," 1990 Sept. 28.

T-10 W-M. Boerner, Final Report on the "Visitation of Ten (10) Buryatian Scientists, Ecologists, Artists, Economists, and State Representatives to Chicago, 1990 Dec 17-to-1991 Jan 02; prepared for US Embassy in the USSR, SPASD House, Moscow, USSR, 1991 Feb 01.

T-11 W-M. Boerner, Final Report on 1991 January 21-31 NATO/GEOS/DLR/ NASA Europe Research Travel by W-M. Boerner including visits to: ONR/LONDON, USARDSG/LONDON; ONERA/PARIS, NATO Hqts/BRUSSELS; SHAPE-TC/SCHEVENINGEN; DLR/OBERPFAFFENHOFEN, TUD & UFL/DRESDEN), 1991 March 15.

T-12 W-M. Boerner, Final Report on 1991 Feb 02-06 CANADA IEEE/RP-S & URSI/NA-RSM, Technical Paper & Planning Committee Meetings, Ottawa Ont/CAN, 1992 Feb 02-04.

T-13 W-M. Boerner, Final Report on 1991 Sept. 12 - Oct. 12, NATO/ESA/ CEOS-NASA/DLR/ISAR Research Travel, 1991 Dec. 15.

6.2 Public Forums and Hearings (attended on behalf of the University of Illinois at Chicago and as a Private Citizen Residing within the 10th Congressional District of Illinois) (F-1 to F-17).

F-1 1989, February 25: Public Forum on Fort Sheridan, Convened by the Honorable John E. Porter, Congressman (R:10th Congressional Distr, IL): **Presentation of the Concept of Creating a "Great Lakes Environmental, Ecological Graduate Education and Research Center for the Preservation of the Great Lakes Environment within Fort Sheridan"**, by W-M. Boerner, private citizen residing within 10th Congressional District of Illinois (on Forum Records, 5 min.).

F-2 1989, April 22: Public Forum on "Education Reform: Raising America's Grade", convened by the Honorable John E. Porter, Congressman (10th Cong. Distr., IL), **"Raising America's Grade in Education Must Start by Educating Its People on How to Preserve Its Environment"**, by W-M. Boerner, private citizen residing within 10th Congressional District of Illinois (on Forum Records: 8 minutes).

F-3 1989, May 13: Public Forum on **"Gobal Warning: Too Hot to Handle"**, convened by the Honorable John E. Porter, Congressman (R: 10th Congr Distr of IL) **"Both Military and Industrial Expansion and the Population Explosion must be Controlled: No Single Nation, Large or Small, Can Any Longer Indulge in the Luxury of Waging Military, Industrial and/or Population-Explosive Warefare and Instead We Must Learn to Refunnel all Available and Newly Committed Resources to the Environmental Clean-up Problem for the Global Benefit for a "Pan-Terrestrial Community of all World Citizens"**, i.e., we must rapidly advance the concept of "Global Environmental Planetary Defense" to become a strong integral component of our US Department of Defense (Dr. W-M. Boerner, 10 minutes on record).

F-4 PUBLIC HEARING OF 1989 April 24th: 1-6 PM, Ft. Sheridan, Lake County, IL, Bldg. 31, Ballroom on "The Future Re-Use and/or Recommissioning of Fort Sheridan", convened by the Honorable John E. Porter, Congressman (R:

10th Congr. Distr. of IL) on behalf of the Fort Sheridan Consortium: **"RECOMISSIONING OF A SUBSTANTIAL PART OF FORT SHERIDAN TO HOUSE A "GREAT LAKES ENVIRONMENTAL & AERONOMIC GRADUATE EDUCATION & RESEARCH CENTER" IN A MARITIME CONSERVATION AND LAKEFRONT RECREATION PARK"**, UIC Public Statement of 1989 April 14, presented on behalf of the UIC Vice Chancellor for Research by Dr. Wolfgang-M. Boerner, Private Citizen and UIC Professor, Residing in the 10th Congressional District of Illinois.

F-5 PUBLIC HEARING of 1989, May 30: to discuss **"THE SCOPE OF AN ENVIRONMENTAL IMPACT STATEMENT (EIS) ON THE PROPOSED CLOSURE OF FORT SHERIDAN, LAKE COUNTY, IL"**, convened by the Department of the Army, US Army Engineer District, Louisville Corps of Engineers, Dr. Robert G. Fuller, Acting Chief, Planning Division, Environmental Analysis Branch/Public Note #89-LD/PD-010): **"RECOMISSIONING OF A SUBSTANTIAL PART OF FORT SHERIDAN TO HOUSE A "GREAT LAKES ENVIRONMENTAL & AERONOMIC GRADUATE EDUCATION & RESEARCH CENTER" IN A MARITIME CONSERVATION AND LAKEFRONT RECREATION PARK"**, UIC Public Statement of 1989 April 14, presented on behalf of the UIC Vice Chancellor for Research by Dr. Wolfgang- M. Boerner, Private Citizen and UIC Professor, Residing in the 10th Congressional District of Illinois.

F-6 PUBLIC HEARING of 1989, June 16: to discuss the responsibities and judicial rights for the members of the **"FORT SHERIDAN COMMISSION"**, and the incorporation of the Commission: To form a group of local, state and federal officials, as well as, private citizens, to facilitate and promote the creation of a concensus land re-use plan for the Fort Sheridan, Lake County, IL., after it converts from military to civilian use.

F-7 PUBLIC HEARING of FORT SHERIDAN COMMISSION, 1989 October 07: Establishment of Commission Panels and Election of Panel Members (W-M. Boerner, member of EDUCATION PANEL, & PANEL OF THE ADVOCATES FOR THE PUBLIC INTEREST IN FORT SHERIDAN).

F-8 PUBLIC FORUM, FORT SHERIDAN COMMISSION, EDUCATIONAL & ENVIRONMENTAL PANELS, 1990 December 07: Presentation of Position Paper by W-M. Boerner, on the **NEED FOR THE ESTABLISHMENT OF AN INTERNATIONAL & JOINT US-CANADIAN FACILITY OF THE MIDWEST FOR EDUCATION, RESEARCH TECHNOLOGY AND PRESERVATION IN GREAT LAKES CLIMATOLOGY, ECO-SYSTEMS, COSTAL & MARINE ENVIRONMENTS AT FT. SHERIDAN, LAKE COUNTY, ILLINOIS (Submitted to FSC on 1990 January 29).**

F-10 PUBLIC FORUM, FORT SHERIDAN COMMISSION, EDUCATIONAL PANEL, 1990 February 13: Presentation of Position Paper on the "ROLE OF EDUCATION", in the future re-use of Ft. Sheridan by W-M. Boerner.

F-11 INVITATION by the International Joint Commission, Great Lakes Science Advisory Board, Council of Great Lakes Research Managers, ELEVENTH MEETING OF THE COUNCIL OF GREAT LAKES RESEARCH MANAGERS, US EPA, Large Lakes Research Station, Grosse Ile, MI, 1990, March 8 - to - 10; **COMMISSION on the ESTABLISHMENT of an INTERNATIONAL CENTER FOR GLOBAL RESEARCH**: (1) The Creation of International Science, Technology and Environmental Preservation Parks, Cities, Metropoles and Meglopoles in Japan and FR Germany; (2) **"FORT SHERIDAN: Could it serve as ideal location for the Establishment of the INTERNATIONAL JOINT US- CANADIAN CENTER FOR GLOBAL ENVIRONMENTAL RESEARCH WITHIN THE GREAT LAKES".**

F-12 PUBLIC FORUM, FORT SHERIDAN COMISSION, EDUCATIONAL & ENVIRONMENTAL PANELS, 1990 April 26, Presentation of Position Paper on **"Role of Education in Global Environmental Planetary Defense"**, in the future re-use of Ft. Sheridan by W-M. Boerner.

F-13 **PUBLIC HEARING OF FORT SHERIDAN COMMISSION, 1990 May 31, Submission of a position paper on the "NEED FOR THE ESTABLISHMENT OF AN INTERNATIONAL & JOINT US-CANADIAN FACILITY OF THE MIDWEST FOR EDUCATION, RESEARCH TECHNOLOGY AND PRESERVATION IN GREAT LAKES CLIMATOLOGY, ECO-SYSTEMS, COASTAL & MARINE ENVIRONMENTS AT FT. SHERIDAN, LAKE COUNTY, ILLINOIS", presented to FSC.**

F-14 Elected "US NAVY ASEE (American Association for Engineering Education), SFRP (Summer Faculty Research Program), Distinguished Senior University Fellow (award) on **"Ultra-wideband Electromagnetic Wide Area Environmental Surveillance of the Ocean Sea Surface and Coastal Regions, for the Instantaneous Localization, Ranging, Detection Specification and Identification of Environmental Pollutants and Naval Threats"**, Naval Ocean Systems Center, San Diego, CA, 1990 June 01 - September 30 (in collaboration with NWC,PMTC,NADC,DTRC,NRL,NSWC,NCSC,NOARL,MI-COM,LANL and RADC): Presentation of various position papers on the urgent need for **upgrading priorities on Global Planetary Defense versus National Defense issues.**

F-15 Elected official delegate on behalf of UIC and the Illinois State Governor's Office, for the US-USSR Environmental Preservation Program on **"Save the Terrestrial Large Lakes: Save the Great Lakes Baikal/Michigan Environmental Theatre Festival"**, Ulan Ude and Baikal Lake, Buryato, Southeastern Siberia, USSR, 1990 August 18 - September 04, Presentation of Several Position Papers during Environmental Scientific Workshops and Retreats.

F-16 INVITATION by the International Joint Commission, Great Lakes Science Advisory Board, Council of Great Lakes Research Managers, **TWELFTH MEETING OF THE COUNCIL OF GREAT LAKER RESEARCH MANAGERS, ECOSYSTEMS MODEL WORKSHOP, Milwaukee, WI,** 1990 Dec 4-6; International Global Environmental Assessment Commission Panel, **"The Boreal Large Lakes - Environmental/ Ecological Research Exchanges: Great Lakes - Lake Baikal".**

F-17 **PUBLIC TESTIMONY PRESENTED ON BEHALF OF THE UNIVERSITY OF ILLINOIS AT CHICAGO DURING THE PUBLIC HEARING ON FORT SHERIDAN,** Saturday, 1991 February 23, 10:00 - to - 10:00 on the topic of

RECOMMISSIONING A SUBSTANTIAL PART OF FORT SHERIDAN TO HOUSE AN INTERNATIONAL "GREAT LAKES CENTER" FOR ENVIRONMENTAL, ECOLOGICAL, AERONOMIC & CLIMATOLOGIC EDUCATION, RESEARCH, POLICY & ARTS IN A MARITIME CONSERVATION AND LAKEFRONT RECREATION PARK: "THE FORT SHERDIAN GREAT LAKES CENTER" in coordination with establishing all wet-bed environmental laboratories within the nearby **WAUKEGAN HARBOUR** site, of Lake County, Illinois; with the objective to:

REQUEST FROM THE FEDERAL GOVERNMENT THE RECOMMISSIONING BY DONATION OF THE ENTIRE FACILITY FOR SAID PURPOSE WITH SHARED STATE, FEDERAL & INTERNATIONAL SUPPORT FOR CONTINUING FUTURE OPERATION AND FACILITIES MAINTENANCE (Detailed Position Paper: 16 pages/attached to this Report).

6.3 Honors and Citations Awarded (H-1 to H-16)

H-1 Alexander von Humboldt-Stiftung (FR Germany), Senior U.S. Scientist Award, the Humboldt (Preis) Award, in recognition of past accomplishments in research and teaching, and for the promotion of scientific cooperation between DFVLR-Oph. (Dr. Wolfgang Keydel) and the U.S.; awarded for a nine month period, beginning July 1, 1986 (executed: 1987, Jan. 1 - July 31; 1988 Aug. 15 - Oct. 15; 1989 April; 1989, Nov. 1 - 15:).

H-2 The Japan Society for the Promotion of Science, US Senior Scientist Fellow Award, for the **"Advancement in Electromagnetic Imaging and Radar Polarimetry"**, August 1, 1986; renewed 1988 August (for three years).

H-3 The Royal Society of Norway, US Senior Scientist Fellow Award, for the **"Advancement of Radar Polarimetry in High Resolution Radar Imaging"**, Feb. 1987, Summer 1990 (3 months).

H-4 The Chinese Academy of Science and Technology, Senior Scientist Fellow Award, May 1988 (Xian/Beijing, P.R. China) for **"The Advancements of Electromagnetic Inverse Scattering"**.

H-5 The Polish Academy of Science, 1988 National Award to Senior International Scientists for the **"Advancement of Inverse Methods in High Resolution Radar Imagery"**, October 1988 (Gdansk/Warszawa, Poland).

H-6 The USSR Academy of Science, Lenin Medal for Scientific Achievement, 1989 May 17/May 21, Moscow/Leningrad for promotion of **"Direct and Inverse Methods in Radar Polarimetry"**.

H-7 The University of Illinois Senior Scholar Award: 1989 - 1992, 1988 July 15, for the advancement of "Direct and Inverse Methods in Radar Polarimetry.

H-8 Election into "Electromagnetics Academy for Contributions to "Direct and Inverse Methods in Radar Polarimetry, 1989 Dec. 15.

H-9 Appointment ot Great Lakes Science Advisory Board, Council of Great Lakes Research Managers, International Joint (US-CANADA) Commission, 1990-1993.

H-10 The US NAVY-ASEE-SFRP-Distinguished Senior Professor Award, 1990 April.

H-11 Offical Delegate on behalf of UIC and the Illinois State Governor on the Illinois delegation for the "Save the Great Lakes Baikal/Michigan Environmental Theatre Festival", Lake Baikal and Ulan Ude, Buryat, Siberia, USSR, 1990 August 17 - September 04.

H-12 The International Information Science Foundation of Japan Senior Scientist Award on "USA-Japan Research Interaction and Exchange of Advanced Research in Information and Sensing Sciences on "Radar Polarimetry and Diffraction Tomography and on "Seismo-electromagnetology", 1990 September 07 - October 03.

H-13 Elected and Appointed Member, Advisory Board, **Baikal International Center for Ecological Research** (BICER), Lystianka, Lake Baikal, East Siberia, USSR.

H-14 Appointed by US Congressional Committee on US Military Base Closures for

determining the "RE-USE OF THE HISTORICAL SECTION OF FORT SHERIDAN AS A GREAT LAKES INTERNATIONAL CENTER FOR ENVIRONMENTAL RESEARCH, EDUCATION & POLICY", 1991 February 28.

H-15 The US NAVY-ASEE-SFRP-Distinguished Professor Award, 1991 March 15.

H-16 The Polish Academy of Sciences, Invitation to present a major keynote address during **'Plenary Sessions of MIKON'91** with selected title of **"Radar Polarimetry"**, Rydzyna Castle, Poland, 1991 May 22.

6.4 **National and International Review Boards, (N-1 to N-10)**

N-1 1989 Nov. 7-9: Institute Review, German Aerospace Research Establishment, Electromagnetic Probing and Remote Sensing Division, DFVLR-NE-HF, Oberpfaffenhofen, FRG-West Germany (Elected Member by FRG-Ministry of Science & Technology, DFG and DLR- OPH);

N-2 1989 Nov. 8-10: Elected Member, Board of Planners, FRG Science & Technology Metropolitan Park Grossraum Müchen Project, Planning Committees Meeting, Commission: Environmental Preservation, 1989 November 8-10, Oberpfaffenhofen, FRG.

N-3 1989 Nov. 15-17: Appointed Member, Board of Planners, Kansai Science City Project, Planning Board -- C: Universities, Subcommittee Environmental Preservation, Kyoto, 1989 November 15-17, Kyoto, Japan.

N-4 1990 March 01-04: US Department of Defense, Panel for Evaluating Applicants to the National Defense Science & Engineering Graduate Fellowship Program, Battelle RTP Office, 1990 March 2-4.

N-5 1990 March 08-10: Int'l Joint Commission, Great Lakes Science Advisory Board, Panel on Education and Research, US EPA, Large Lakes Research Station, Grosse Ile, MI, Saturday, 1990 March 10.

N-6 1990 June 01 - September 30: US Navy/DARPA Advisory Panel on Ultrawide-band Impulse Radar Theory, Metrology and Technology.

N-7 1990 December 4-6: Int'l Joint Commission, Great Lakes Science Advisory Board, Ecosystem Model Workshop, Milwaukee, WI.

N-8 1990 December 15 - (Standing Advisory Committee), Baikal International Center for Ecological Research, Lystianka, Lake Baikal, Irkutsk Region, RSR of Siberia.

N-9 1991 September 24-25: FRG, Ministry of Science & Technology, Advisory Committee on the "Integration of former DDR, Akademie der Wissenschaften, Forschungs-Institute Berlin-Adlershof' into DLR-Research Centers", and the "Establishment of the DLR Institute for Terrestrial & Planetary Remote Sensing at Berlin-Adlershof".

N-10 1991 October 8-10: Kultusministerium des Freistaates Sachsen, Advisory Committee for the Integration of all of the eight(8) major Institutes of Secondary Education of Dresden, Saxony into the "Universität, Dresden", Subcommittee on the Integration of Technical Institutes (TUD and HSV).

6.5 **Biographies of Workshop Director (biographies of Co-Directors, W-M.**

Boerner and W. Keydel, and short-form biographies of Associate Directors, are on file).

6.5.1 BIOGRAPHIES OF CO-DIRECTORS, 1990 November 12

WOLFGANG-M. BOERNER was born on July 26, 1937 in Finschhafen, Papua-New Guinea. He received his Arbitur (B.L.A.S.) from the August von Platen Gymnasium, Ansbach, West Germany in 1958; his Dipl-Ing. (M.Sc.) degree from the Technische Universität München in 1963; and his Ph.D. degree from the Moore School of Electrical Engineering, The University of Pennsylvania, Philadelphia, PA in 1967.

From 1967 to 1968 he was employed as a Research Assistant Engineer at the Department of Electrical & Computer Engineering, Radiation Laboratory, University of Michigan, Ann Arbor, MI, involved in inverse scattering investigations. During the summer of 1968 he joined the Electrical Engineering Department, University of Manitoba, Winnipeg, Canada, first as a Postdoctoral Research and Teaching Fellow and then as a faculty member, where he became professor in 1976 and continued his research in electromagnetic inverse problems and remote sensing. During the period of July 1975 to 1976 he spent his research year of leave, in part, as a Humboldt Fellow at the Universität Nürnberg in Erlangen, FR Germany (Prof. Dr.-Ing. Hans Brand); and at the University of Canterbury in Christchurch, New Zealand (late Prof. Richard H.T. Bates, D.Sc.), extending his research interests into geoelectromagnetism, which is currently further expanding to include seismo-electromagnetology. In 1978, he joined the Department of Electrical Engineering & Computer Science, University of Illinois at Chicago, where he is currently Professor & Director of the Communications & Sensing Laboratory in the College of Engineering. During 1986-1987 he spent his sabbatical research leave from UIC, in part, as a U.S. Senior Scientist Award Fellow of the Japan Society for the Promotion of Science; of the People's Republic of China's Association of Science and Technology; of the Norwegian Society of Science and Technology; and of the Humboldt Foundation for the Promotion of Science and Technology in Tsukuba, Japan; in Xi'an, Shaanxi Province, P.R. China; NTNF-Kjeller, Norway; and DFVLR-Oberpfaffenhofen, West Germany, respectively.

During 1988 - to - 1989, he was repeatedly invited by the Academy of Sciences of Poland and of the USSR as a Visiting Professor, and he is currently the recipient of the University of Illinois Scholar Award (1989-1992) and of a US NAVY-ASEE-SFRP Distinguished Senior Professor Award (1990-1992). He served as an official member of the Chicago and State of Illinois delegation for the US-USSR Terrestrial Large Lakes Preservation program at the "Save the Terrestrial Great Lakes Baikal/ Michigan Environmental Theatre Festival" in Ulan Ude and Lake Baikal during 1990 August 19 -to- September 04, and since then has become a member of the Advisory Board of BICER, the Baikal International Center for Ecological Research, Listvyanka, Southwest Baikal Lake.

He is a member of the Canadian Association of Physicists, Sigma Xi, the Society of Photo-Optical Instrumentation Engineers, the Optical Society of America, the Society of Exploration Geophysicists, the Society of Engineering Sciences, the American Association for the Advancement of Science, and the Fulbright Alumni Association; and he is a member of the U.S. Commissions B, C, E, and F of the International Scientific Radio

Union. He is also a Fellow of the IEEE, of the Humboldt Society for the Advancement of Science of the Federal Republic of Germany, and of the Japan Society for the Promotion of Science. He is currently the recipient of the University of Illinois Senior Scholar Award for 1989-1992.

6.5.2 SHORT BIOGRAPHY, 1991 August 30

WOLFGANG KEYDEL was born on July 11, 1936 in Berlin, Germany. He received his matura from the Alte Humanistische Gymnasium in Bamberg, Franconia, FRG in 1954 and the Abitur (B.L.A.S.-Junior) from the Humanistische Friedrichs Gymnasium at Kassel, FRG in 1956; his Dipl.-Phys. (M.Sc. Phys.) from the Philipps University Marburg in 1963, upon studies in mathematics and physics at the Universities in Hamburg and Marburg; and his Dr. re. nat.(Phys.) also from the University of Marburg in 1967.

From 1963 to 1967, he was a Research Assistant with the Applied Physics Institute of Prof. Wolter at the Philipps University Marburg, engaged in a dissertation on "near field analysis and measurements of conic antennas with elliptic cross-sections". During 1968 to 1978, he was with AEG-Telefunken, Ulm, FRG, first as a research physicist, then from 1969 to 1977, he was the Head of the Department of Basic Studies within the Division of Electronic Aviation Systems; thereafter, he was Head of the Department for Audio/Video Telecommunications and Data Processing, with the Electronics Division of AEG-Telefunken, Ulm/FRG. During his active tenure as engineering scientist, he was involved in the development and advancement of modern radar systems, producing many confidential company-internal reports, numerous technical papers and monographs, and he also holds several important patents on fusing antenna design.

Since 1978, he has been with the German Aeronautical & Aerospace Research and Test Organization, the DFVLR (Deutsche Forschungs-und Versuchs-Anstalt für Luft-und Raum-fahrt, e.V.), recently renamed to DLR (Deutsche Luft-und-Raum-fahrt), as the Director of the Institute for Radio Frequency Technology, at Oberpfaffenhofen near Munich in Bavaria, FRG. He is in command of a staff of about 120 with about 70 scientists engaged in studies of electromagnetic remote sensing and sounding, telemetry and tele-navigation, satellite and aircraft communications and tracking; radar theory, metrology and data processing; and electromagnetic wave propagation, scattering and diffraction with applications to radar target and clutter analysis, radar corss-section estimation and metrology; modelling of the propagation path, the design of antenna sensors, and tracking systems, etc.

Currently, he is also involved as the Chief Advisor for the Integration of former East German, Academy of Sciences, Graduate Education and Research Institutes into the DLR organization, and in particular, the transition of the former DDR-AdW-KOSMOS-Institute of Berlin-Adlershof into: (i) the DLR, Institute for Planetary & Space Research; and (ii) the DLR, Institute for AI Space Remote Sensors, both of Berlin-Adlershof.

Dr. Wolfgang Keydel has also contributed most profoundly to improving international collaboration in various fields of terrestrial and planetary remote sensing, tele-navigation and positioning as well as to Very Long Base Line Interferometery (VLBI) with application to geodesy and the dynamics of terrestrial plate tectonics.

He is a member of many national and international organizations and societies including VDE, DEGON, IEEE, GRS-S, URSI-F, VDI-ITG, and he is also a Panel Member of NATO-AGARD-AVP, and its German Coordinator for Areal Remote Sensing, Satellite Tele-Communication & Tele-Sensing Systems as well as Tele-Navigation and Positioning.

6.2 Short-Form Biographies of Associate Directors on File

(available upon request)

Hans Brand
High-Frequency Engineering Laboratory
Univ. Erlangen-Nürnberg, FR Germany

Leonard A. Cram
Thorn EMI, Electronics Ltd., UK

William A. Holm
GTRI-RAIL/MAL
Atlanta, GA/USA

David E. Stein
Westinghouse Electric Corporation
Baltimore, MD/USA

Werner Wiesbeck
IHE, University of Karlsruhe
Karlsruhe, FR Germany

Dino Giuli
Radar Research Lab.
Dept. of Electronics Engineering
Univ of Florence, Ital

Dag T. Gjessing
ESTP, Royal Norwegian Council of
Industrial and Scientific Rsch.

Frédéric A Molinet
Société Mothesim
Le Plessis-Robinson, France

7. APPENDICES

7. APPENDIX

FINAL TECHNICAL PROGRAM OUTLINE

NATO-ARW-DIMRP '88
on
DIRECT & INVERSE METHODS IN RADAR POLARIMETRY

Kur und Kongress Hotel Residenz, Bad Windsheim, FRG

Dedicated to: Jean Richard Huynen

1988 September 18-24

SUNDAY, 18 SEPTEMBER 1988

10:00 to 12:00 - **WORKSHOP DIRECTORS' MEETING** (Room A)
Director: WOLFGANG-M. BOERNER, UIC, Chicago, USA
Co-Directors: HANS BRAND, Univ. Erlangen-Nürnberg, FRG
LEONARD A. CRAM, THORN-EMI, Wells, Somerset, England
DINO GIULI, Univ. of Florence, Italy
DAG T. GJESSING, NTNF, Kjeller, Norway
WILLIAM A. HOLM, GIT-RAIL, Atlanta, USA
WOLFGANG KEYDEL, DFVLR, Oberpfaffenhofen, FRG
ERNST LÜNEBURG*, DFVLR, Oberpfaffenhofen, FRG
FRÉDÉRIC MOLINET, Soc. Moth., Le Plessis-Robinson, France
GERD SCHALLER, UEN, Erlangen, FRG
DAVID E. STEIN, USAFR, Baltimore, USA
MARTIN VOGEL*, DFVLR, Oberpfaffenhofen, FRG
WERNER WIESBECK, TUK, Karlsruhe, FRG
(* unable to participate)

12:00 to 13:00 - **LUNCH BREAK**

13:30 - **DEPARTURE OF WORKSHOP BUS "ARW-DIMRP-KUK, BAD WINDSHEIM,"** (Thürauf:white-orange) from Frankfurt Airport Bus Station (opposite Main Arrival Hall B - lower level): **see Travel Instructions, Travel Questionnaire, and Terminal Guide Map**

14:30 - **DEPARTURE OF WORKSHOP BUS "ARW-DIMRP-KUK, BAD WINDSHEIM,"** (Thürauf:white-orange)from Nuremberg Central Station (main station exit towards city: Bahnhofsplatz): see **Travel Instructions and Travel Questionnaire**

15:30 to 18:30 - **REGISTRATION AND RECEPTION** -
(Foyer of Congress-Center and Rm. A)
DR.-ING. GERD SCHALLER, UEN, Erlangen, FRG
FRAU MONIKA KUEHL, UEN, Erlangen, FRG
DR.-ING. SIEGFRIED OSTERRIEDER, GHS, Ravensburg, FRG
MAJOR DAVID E. STEIN, USAFR, Baltimore, MD/USA
DR.-ING. HELMUT SÜSS, DFVLR, Oberpfaffenhofen, FRG
DIPL.-ING. KARL-HEINZ BETHKE, DFVLR, Oberpfaffenhofen, FRG
DR.-ING. MAURICE BORGEAUD, DFVLR, Oberpfaffenhofen, FRG
HERR REINER WEPPNER, DFVLR, Oberpfaffenhofen, FRG

17:30 to 19:30 - SUPPER IN THE RESTAURANT BRÜCKE
Hosts: HERR ROLF K. ERLENBACH, KUK-Hotel Residenz, Manager
FRAU JUTTA BROCKHOFF, KUK-Hotel Residenz, Vice-Manager

20:00 to 21:55 - **OPENING SESSION (O)**
Chairman: PROF. DR. DAG T. GJESSING
Norges Teknisk-Naturvitenskapelige Forskningsrad, Kjeller
and University of Tromsö, Tromsö, Norway

20:00 - OPENING REMARKS
(Foreword) PROF. W-M. BOERNER, UIC-EECS, Chicago, IL/USA

20:10 - INTRODUCTION OF DIRECTORS AND GUESTS OF HONOR
MR. LEONARD A. CRAM, THORN-EMI, Wells, UK

20:20 - WELCOME ADDRESS BY HOST INSTITUTE
(Address) DR. WOLFGANG KEYDEL, DFVLR, Oberpfaffenhofen, FRG

20:30 - TECHNICAL PROGRAM DESCRIPTION

O-1*: Historical Development of Radar Polarimetry - Unresolved Problems - Incentives for this Workshop
PROF. WOLFGANG-M. BOERNER, UIC-EECS, Chicago, IL/USA

20:40 - OPENING LECTURE

O-2*: POLARIZATION IN NATURE
DR. GÜNTHER P. KÖNNEN
K.N.I. deBilt, Utrecht, NL

21:40 - SPOUSES' TOUR AND CULTURAL PROGRAM DESCRIPTIONS
(Foreword) DR.-ING. SIEGFRIED OSTERRIEDER, FHS, Ravensburg, FRG
DR.-ING. HELMUT SÜSS, DFVLR, Oberpfaffenhofen, FRG

21:55 - GREETINGS AND WISHES FOR A SUCCESSFUL WORKSHOP
(Foreword) MR. ROLF K. ERLENBACH, KUK-Hotel Residenz, Manager
FRAU JUTTA BROCKHOFF, KUK-Hotel Residenz, Vice-Manager

22:00 - **DAY'S END: "Hotel at Rest"**
(See KUK-Hotel Residenz Information)

* all numbered presentations will appear as papers in the Workshop Proceedings

MONDAY, 19 SEPTEMBER 1988

6:00 - **MORNING CALL**

6:45 to 7:45 - **BREAKFAST**

SESSION I

8:00 to 10:00 - **BASIC POLARIZATION THEORY**
Chairman: DR. FRÉDÉRIC MOLINET
Société Mothesim, Le Plessis-Robinson, France

8:00 - I-1: Definitions of Polarization in Radar
I-1 PROF. HAROLD MOTT
Univ. of Alabama, University, AL/USA

8:30 - I-2: Fundamental Equations of Radar Polarimetry
(replaced by) DR. ALEXANDER B. KOSTINSKI
I-2 WOLFGANG-M. BOERNER
UIC-EECS/CL, Chicago, IL/USA

9:00 - I-3: An Alternative Approach to Foundations of Radar
I-3 Polarimetry
DR. ZBIGNIEW H. CZYZ
Przemystowy Instytut Telekomunikacji, Warszawa, Poland

9:30 - I-4: Basic Polarimetric Signatures of Targets and Clutter
IV-7 DR. WILLIAM A. HOLM
Georgia Inst. of Technology/RAIL, Atlanta, GA/USA

10:00 to 10:30 - **COFFEE BREAK**

SESSION II

10:30 to 12:30 - **FOUNDATIONS OF RADAR POLARIMETRY**
Chairman: PROF. DOMINICO SOLIMINI
University Tor Vergata, Roma, Italy

10:30 - II-1: Polarimetric Target Decomposition Theory
I-7 DR. J. RICHARD HUYNEN
P.Q. Research, Los Altos Hills, CA/USA

11:00 - II-2: Optimal Reception of Partially Polarized Waves
(replaced by) DR. ALEXANDER B. KOSTINSKI
I-5/I-6 MR. BRIAN D. JAMES
PROF. WOLFGANG-M. BOERNER
UIC-EECS/CL, Chicago, IL/USA

11:30 - II-3: Fundamentals of Statistical Polarimetry
I-4 DR. SHANE R. CLOUDE
Univ. of Dundee, Dundee, Scotland, UK

12:00 - II-4: Time Variant Polarimetric Vector Data Representation
IV-1 Using Geometric Interpretations of Wave and Scattering Matrices
DR.-ING. GERD WANIELIK
AEG Aktiengesellschaft, Ulm/Donau, FRG

12:30 to 13:45 - **LUNCH BREAK**

SESSION III

13:45 to 15:15 - **POLARIMETRIC RADAR CONCEPTS**
Chairman: PROF. WERNER WIESBECK
Technical University Karlsruhe, Karlsruhe, FRG

13:45 - III-1: The Theory and Measurement of Surface Torsion
II-6 DR. RICHARD J. HUYNEN
P.Q. Research, Los Altos Hills, CA/USA

14:15 -III-2: Inverse GTD via Polarimetric Linear Prediction
II-4 PROF. HEINZ CHALOUPKA
University Wuppertal, Wuppertal, FRG

14:35 - III-3: Specular Target Geometry and Scattering Matrices
(replaced) PROF. BING-YUEN FOO
II-1/II-2 DePaul University, Chicago, IL/USA
PROF. SUJEET K. CHAUDHURI
Univ. of Waterloo, Waterloo, ONT/Canada
PROF. WOLFGANG-M. BOERNER
UIC-EECS/CL, Chicago, IL/USA

14:55 - III-4: A Polarimetric Model for Multipath
II-10 Imaging/Identification Analyses
PROF. SUJEET K. CHAUDHURI
University of Waterloo, Waterloo, ONT/CAN
PROF. WOLFGANG-M. BOERNER
UIC-EECS/CL, Chicago, IL/USA

15:15 to 15:45 - **TEA BREAK**

MEETING WDG-1

15:45 to 17:45 - **WORKING DISCUSSION GROUP(S) MEETING**
Chairman: MR. LEONARD A. CRAM
IX-0 THORN-EMI, Wells, Somerset, England, UK

15:45 - ORGANIZATION OF WORKING DISCUSSION GROUPS
IX-0 PROF. WOLFGANG-M. BOERNER
UIC-EECS/CL, Chicago, IL/USA

15:55 - INTENT, PURPOSE, AIM OF WORKING DISCUSSION GROUP MEETINGS
IX-0 DR. DAG T. GJESSING
Norges Teknisk-Naturvitenskapelige Forskningsrad
Kjeller, Norway

16:05 - GUIDELINES FOR PREPARATION OF WORKING DISCUSSION GROUP REPORTS
IX-0 DR.-ING. HELMUT SÜSS
DFVLR, Oberpfaffenhofen, FRG

16:15 - SEPARATION INTO SIX SPECIFIC WORKING DISCUSSION GROUPS AND DISTRIBUTION OF QUESTIONNAIRES AND ADDITIONAL INFORMATION (see details in "Information on Working Group Discussion...")

IX-1 W-A: Assessment of Literature on Polarimetric Theory & Applications
Coordinators: G. Wanielik and V.N. Bringi

IX-2 W-B: Polarimetric Target and Clutter Analyses: (Direct Scattering)
Coordinators: A. Rossettini and Y.M.M. Antar

IX-3 W-C: Polarization Diffraction Tomography: Sensing of Concealed Objects
Coordinators: H. Blok and H. Hellsten

IX-4 W-D: Unification of Nomenclature, Conventions & Standards in POL-RAD/SAR/ISAR Imaging
Coordinators: A. Blanchard and D. Stock

IX-5 W-E: Processing, Formatting & Calibration of POL-RAD/SAR/ISAR Measurements
Coordinators: J. van Zyl and G.A. Mueller

IX-6 W-F: Acceleration of Int'l/NATO Interaction: Design of INT-NATO POL-RAD/SAR Measurement Campaigns (Administrative)
Coordinators: E. Mosharr and J.L. Eaves

17:45 - **ADJOURNMENT**

17:50 to 18:40 - **SUPPER**

18:45 to 21:45 - **VISIT OF DOWNTOWN BAD WINDSHEIM AND RECEPTION AT CITY HALL**
(Foreword)

19:00 - DEPARTURE WITH GUIDE FROM KUK-HOTEL RESIDENZ

19:20 - ARRIVAL AT CITY HALL

19:30 - RECEPTION BY FIRST MAYOR, OTMAR SCHALLER, AT THE HISTORICAL CITY HALL CHAMBER

20:45 - RETURN TO HOTEL OR VISIT TO LOCAL PUBS

22:00 - **DAY'S END: "Hotel at Rest"**

TUESDAY, 20 SEPTEMBER 1988

6:00 - **MORNING CALL**

6:45 to 7:45 - **BREAKFAST**

SESSION IV

8:00 to 10:00 - **POLARIMETRIC RADAR METROLOGY & SYSTEMS**
Chairman: MR. JERRY EAVES
GIT-RAIL, Atlanta, GA/USA

8:00 - IV-1: VI-7 — Polarimetric Integrated Antennas Composed of Microstrip Patches
PROF. KIYOHIKO ITOH
Hokkaido Daigaku
Sapporo, Hokkaido, Japan

8:30 - IV-2: VII-10 — Polarimetric Processing of Wideband ISAR Images from Distributed Targets
PROF. ANDREW BLANCHARD
PROF. ADRIAN K. FUNG
University of Texas at Arlington, Arlington, TX/USA

8:50 - IV-3: V-6 — Submillimeter Wavelength Modeling of Dielectric Materials in Polarimetric Radar Approaches
DR. ROBERT H. GILES, A.P. FERDINAND, M.J. COULOMBE, JOHN WALDMAN
University of Lowell Research Foundation, Lowell, MA/USA

9:10 - IV-4: III-8 — Polarimetric Target and Clutter Scattering Matrix Measurements at CW to Sub-MM Wavelengths
MR. G.N. JEPPS
Radar Electronics Div., THORN-EMI,
Wells, Somerset, England, UK

9:30 - IV-5: (replaced) VI-6 — Advances in Non-Invasive Temperature Imaging Utilizing Microwave Correlation Radiometers
DR.-ING. GERD SCHALLER
PROF. HANS BRAND
University of Erlangen-Nürnberg, Erlangen, FRG

10:00 to 10:30 - **COFFEE BREAK**

SESSION V

10:30 to 12:30 - **CALIBRATION OF POLARIMETRIC RADAR AND POL-SAR SYSTEMS**
Chairman: DR. HELMUT BRENNER
Siemens AG, Radio & Radar Div., Unterschleissheim, FRG

10:30 - V-1: III-7 — Assessment of Calibration Procedures for Polarimetric Radar Systems
MR. LLOYD W. ROOT
US Army Missile Command, Redstone Arsenal, AL/USA

11:00 - V-2: III-6 — Understanding Reciprocity in Radar Polarimetry
DR. MATTHEW R. FEINSTEIN
The John Hopkins University, Applied Physics Laboratory, Laurel, MD/USA

11:20 - V-3: VI-2 — A New Type of Radar for Polarimetric Analysis of Targets and Clutter
DR. J.G. GALLAGHER
MR. ADRIAN BRITTON
Polarimetric Radar Section, Electronics Division
RSRE, Malvern, England, UK

11:40 - V-4: V-7 — Radar Signal Representation of Diffraction Limited Polarized Scattering by a Terrain Surface
HANS HELLSTEN
Swedish Defense Research Establishment, Linköping, Sweden

12:00 - V-5: IX-4 — Polarimetric Calibration and Remote Sensing Applications Using an X-C-L-Band POL-SAR
DR. DAN R. SHEEN
DR. ROBERT A. SHUCHMAN
Radar Science Laboratory, ERIM, Ann Arbor, MI/USA

12:30 to 13:45 - LUNCH BREAK

SESSION VI

13:45 to 15:15 - POLARIMETRIC SIGNAL PROCESSING
Chairman: MR. LLOYD W. ROOT
US Army Missile Command, Redstone Arsenal, AL/USA

13:45 - VI-1: IV-1 VI-10 — Advances in Polarimetric Signal Processing
PROF. DINO GIULI
DR.-ING. MONICA GHERADELLI
University of Florence, Florence, Italy

14:15 - VI-2: VI-1 — Performance Evaluation of Polarimetric Signal Algorithms
DR. KENNETH C. STIEFVATER
MICHAEL WICKS
VINCENT VANNICOLA
Rome Air Development Center, Griffis AFB, NY/USA

14:35 - VI-3: IV-6 — Use of Radar Polarimetric Information in Image Processing and Classification
DR.-ING. GERD WANIELIK
DR. DONALD J.R. STOCK
Radar Systems Div., AEG/AG, Ulm, FRG

14:55 - VI-4: VI-8 — Target Adaptive Matched Multifrequency Illumination for Many Challenging Applications Involving Target Classification, Slope Wakes, and Subsurface Objects
DR. DAG T. GJESSING
DR.-ING. JENS HJELMSTAD
NTNF-PFM, Kjeller, Norway

15:15 to 15:45 - TEA BREAK

MEETING WDG-2

15:45 to 17:45 - WORKING DISCUSSION GROUP ACTIVITIES (W-1 TO W-6)
(Discussion within Individual Groups)

17:45 - ADJOURNMENT

17:50 to 18:40 - SUPPER

18:45 to 21:00 - **VISIT TO DOWNTOWN BAD WINDSHEIM AND ORGAN RECITAL**
(foreword) **AT ST. KILIAN**

19:20 - DEPARTURE WITH GUIDE FROM KUK-HOTEL RESIDENZ

19:40 - ARRIVAL AT BAROQUE RENAISSANCE CHURCH, ST. KILIAN

19:45 - GUIDED TOUR THROUGH HISTORICAL CHURCH (GUIDE: MRS. BARBARA LORENZ)

20:15 - ORGAN RECITAL (WORKS BY D. BUXTEHUDE, J. PACHHÂVEL, J.S. BACH, and C. FRANK)
ORGANIST: KANTOR BERND UHLMANN.

21:20 - RETURN TO HOTEL OR VISIT OF LOCAL PUBS

22:00 - **DAY'S END: "Hotel at rest"**

WEDNESDAY, 21 SEPTEMBER 1988

6:00 - **MORNING CALL**

6:45 to 7:45 - **BREAKFAST**

SESSION VII

8:00 to 10:00 - **VECTOR (POLARIZATION) DIFFRACTION TOMOGRAPHY**
Chairman: DR.-ING. ERICH REINHARDT
Siemens AG, MTB, Erlangen, FRG

8:00 - VII-1: Multidimensional Electromagnetic Vector
V-1 Inverse Scattering
PROF. KARL J. LANGENBERG
University of Kassel, Kassel, FRG

8:30 - VII-2: Numerical and Experimental Assessment of Diffraction
V-3 Tomography with Emphasis on Microwave and Ultrasonic Imaging of Buried Targets
DR. DOMINIQUE LESSELIER
SUPERLEC, Gif-sur-Yvette, France

9:00 - VII-3: Polarimetric 94 GHz Imaging-Radar for Autonomous
V-5 Vehicles
PROF. DR.-ING. JUERGEN DETLEFSEN
Technische Universität München, München, FRG

9:30 - VII-4: Near- and Far-Field Polarimetric Inverse Scattering
(replaced) Within the Born or Kirchoff Approximation
V-4 DIPL.-MATH. THOMAS GURKE
University of Kassel, Kassel, FRG

10:00 to 10:30 COFFEE BREAK

SESSION VIII

10:30 to 12:30 - **POLARIMETRIC TOMOGRAPHIC METHODS FOR THE IMAGING OF CONCEALED OBJECTS**

Chairman: PROF. HANS BRAND
University of Erlangen-Nürnberg, Erlangen, FRG

10:30 - VIII-1: (**replaced**) **VI-5** Comparison of Accoustic and Microwave Tomographic Measurements of Concealed Objects
MR. MARKUS VESTER
Siemens AG, Zentral-labor, Erlangen, FRG
PROF. HELMUT ERMERT
Ruhr-Universität, Bochum, FRG

11:00 - VIII-2: (**replaced**) **VI-3** Reciprocity and the Formulation of Electromagnetic Imaging Problems
PROF. HANS BLOK
Delft University of Technology, Delft, NL

11:30 - VIII-3: **V-8** Advanced Signal Processing for a Subsurface Radar System
PROF. TSUTOMU SUZUKI
Chofugaoka, Chofushi, Tokyo, Japan

12:00 - VIII-4: **I-8** Application of the Generalized Pencil of Functions Method to Polarimetric Transient Data Scattered from Buried Objects
DR. TAPAN K. SARKAR
Syracuse University, Syracuse NY/USA

12:30 to 12:40 - **LUNCH BREAK** (Short Sandwich Pick-Up Type Luncheon)

SCI-CUL-TOUR I

12:40 to 21:30 - **SCIENTIFIC/CULTURAL TOUR: HEIDENHEIM/BRENZ-OBERKOCHEN-ULM-DINKELSBUEHL/BAD WINDSHEIM**

Co-Chairmen: DR. RUDOLF GROßKOPF, Director
CARL ZEISS, Electronics R&D Center, Oberkochen, FRG

PROF. DR.-ING. GERHARD BOUCKE, Director
AEG Radio & Radar Systems Div., ULM, FRG

12:40 - DEPARTURE FROM KUK-HOTEL RESIDENZ by Tour Buses

14:30 to 17:30 - VISITS OF CARL ZEISS OR AEG R&D LABORATORIES
(**Foreword**) (as designated by you in the Scientific Tour Questionnaire)

(i) **VISIT OF CARL ZEISS**
Electronics Research & Development Center
Oberkochen/Kochel, FRG

Tour Bus: CZA, maximum of 45 participants
13:00 - Departure from Bad Windsheim. Introduction to Carl Zeiss and welcome during bus ride.
DR. RUDOLF GROßKOPF
14:30 - Arrival and company tour
DIPL.-PHYS. HANS-WERNER FLACK
15:15 - Coffee break
15:30 - Civil products at Zeiss
DR. RUDOLF GROßKOPF
15:50 - Products in military technology at Zeiss
DR. WOLF-DIETER TEUCHERT
16:10 - Laser-radar components. The 10.6 μm CO_2-Laser is the best suited candidate for coherent laser radar applications. The development of cw CO_2-lasers as well as some system aspects will be discussed.
DR. JOACHIM HEPPNER
16:50 - Film showing the technical function and applications of the thermal sight
DIPL.-PHYS. HANS-WERNER FLACK
17:15 - Adjournment
17:30 - Departure for Dinkelsbuehl

(ii) **VISIT OF AEG RADIO & RADAR SYSTEMS DIVISION Ulm/Donau, FRG**

(Foreword)

Tour Bus: AEG, maximum of 45 participants
14:45 - Arrival at AEG-Magirusstraße
15:00 - Welcome address: Organization of AEG and its defense related divisions. Film: Radio and Radar Systems Division
MR. KARL FISCHER
15:30 - MM-Wave Technology
MR. JÖRG SCHROTH
16:00 - Sensors for Target Seeking Ammunition
DR. WERNER SIEPRATH
16:30 - Visitation of the Antenna-Nearfield Range, AEG-Sedanstraße
DR. KLAUS SOLBACH
17:00 - Departure to Dinkelsbuehl
DR. GERHARD BOUCKE

18:30 - ARRIVAL OF BUSES AT DINKELSBUEHL

18:30 to 19:00 - GUIDED TOUR OF DINKELSBUEHL: CENTER CITY, THE MEDIEVAL
(Foreword) CITY HALL AND OF THE GOTHIC CATHEDRAL
19:00 to 20:30 - SUPPER AT "DIE SCHRANNE", WEINMARKT 7, DINKELSBUEHL, FRG

20:30 TO 21:00 - ENTERTAINMENT BY THE "DINKESLBUEHL TRIO"

20:45 - DEPARTURE FROM DINKELSBUEHL TO BAD WINDSHEIM BY TOUR BUSES

21:30 - ARRIVAL AT KUK-HOTEL RESIDENZ

22:00 - DAY'S END: "Hotel at rest"

THURSDAY, 22 SEPTEMBER 1988

6:00 - **MORNING CALL**

6:45 to 7:45 - **BREAKFAST**

BOOKSHELF AND POSTER SESSION IX

7:00 to 22:00 - **POLARIMETRIC TECHNOLOGY** (to be announced)

SESSION X

8:00 to 10:30 - **POLARIMETRIC MULTI-STATIC & MULTI-SPECTRAL IMAGING**
Chairman: DR. RUDOLF HÜPPI
Gruppe für Rüstungsdienste, Bern, Switzerland

8:00 - X-1: **III-1** Basic Polarimetric Measurements on Monostatic or Bistatic Radar Images
DR.-ING. SEBASTIAN RIEGGER
PROF. DR.-ING. WERNER WIESBECK
Technical Univ. Karlsruhe, Karlsruhe, FRG

8:30 - X-2: **(replaced) VI-9** Characterization of Moving Objects by Angle Time Variance Observations
DR. F.N. KONG
PROF. DAG T. GJESSING
NTNF-PFM, Kjeller, Norway

9:00 - X-3: **VII-9** Towards a Polarimetric C-Band Aircraft SAR in The Netherlands
DR. PETER HOOGEBOOM
TNO, Applied Physics Lab, The Hague, Netherlands

9:30 - X-4: **VI-4** Experimental Limitations of Polarimetric Measurements Caused by Faraday Rotators and Quarter-Wave Plates at 35 GHz
DR.-ING. REINHARD HAMMEL
DR. BERND RÖDE
DFVLR, NE-HF, Oberpfaffenhofen, FRG

10:00 - X-5: **VII-7** Use of Copolarization Signatures in SAR Polarimeter Image Interpretation
JORGE V. GEAGA
Northrop Research and Technology Center, Palos Verdes Peninsula, CA/USA

10:30 to 11:00 - **COFFEE BREAK**

SESSION XI

11:00 to 13:00 - **POLARIMETRIC SAR/ISAR IMAGING**
DR. DAN R. SHEEN
ERIM, Ann Arbor, MI/USA

11:00 - XI-1: Classification of Scattering Behavior
VII-1 Using Polarimetric Radar
DR. JAKOB VAN ZYL
CAL-TEC/JPL, Pasadena, CA/USA

11:30 - XI-2: Polarization Filtering of POL-SAR DATA
VII-2 DR. PASCALE DUBOIS
CAL-TEC/JPL, Pasadena, CA/USA

12:00 - XI-3: The Polarimetric Matched Image Filter and its
(replaced) Application to POL-SAR Imaging
VII-5/VII-6 MR. BRIAN D. JAMES
DR. ALEXANDER B. KOSTINSKI
PROF. WOLFGANG-M. BOERNER
UIC-EECS/CL, Chicago, IL/USA

12:30 - XI-4: Theoretical Models for Polarimetric Microwave
V-9 Remote Sensing of Earth Terrain
DR. MAURICE BORGEAUD
PROF. JIN-AU KONG
DR. ROBERT T. SHIN
MIT-EECS/EL, Boston, MA/USA

13:00 to 13:45 - **LUNCH BREAK**

MEETING WDG-3

13:45 to 15:30 - **WORKING DISCUSSION GROUP ACTIVITIES: PREPARATION OF FINAL REPORTS (W-1 to W-6)**
Chairmen: PROF. SUJEET K.CHAUDHURI
University of Waterloo, Waterloo, ONT/Canada

13:45 - PREPARATION OF FINAL REPORTS OF INDIVIDUAL GROUPS W-1 TO W-6
PROF. DAG T. GJESSING
University of Tromsö, Tromsö, Norway

14:30 - TEN-MINUTE SUMMARIES BY EACH GROUP'S REPORTERS*

IX-1	W-A:	PROF. KIYOHIKO ITOH and DR. P. SAMUEL P. WEI
IX-2	W-B:	DR. DAVID E. STEIN and DR. REINHART HAMMEL
IX-3	W-C:	DR. MARKUS VESTER and DR. MAURICE BORGEAUD
IX-4	W-D:	DR. ALEXANDER B. KOSTINSKI and DR. MATTHEW R. FEINSTEIN
IX-5	W-E:	DR. LEO LIGTHART and PROF. TSUTOMU SUZUKI
IX-6	W-F:	DR. WALTER K. FLOOD and DR. RUDOLF HÜPPI

*** Final Group Reports will be published in the Workshop Proceedings**

15:30 - **ADJOURNMENT**

15:30 to 15:45 - **COFFEE BREAK**

15:45 to 21:30 - **VISIT OF THE FRANKONIAN OPEN-AIR MUSEUM** (Registration for Participation and Diet Requests to be forwarded by Tuesday, 1988 Sept. 20 noon to ARW-Sekreteriat, Room A)
(Foreword)

15:45 - DEPARTURE BY BUS FROM KUK-HOTEL RESIDENZ

16:00 to 18:00 - Viewing of OPEN-AIR MUSEUM with Guide

18:00 to 21:00 - "KARPFENESSEN im Museums-Restaurant":
Entertainment by "die Windsheimer Sänger"

21:15 - DEPARTURE OF WORKSHOP BUSES

22:00 - **DAY'S END: "Hotel at Rest"**

FRIDAY, 23 SEPTEMBER 1988

6:00 - **MORNING CALL**

6:45 to 7:45 - **BREAKFAST**

SESSION XII

8:00 to 10:00 - **STATISTICAL METHODS IN POLARIMETRIC REMOTE SENSING**
Chairman: DR. EDWARD MOSHANG
Johns Hopkins Univ., Applied Physics Lab, Laurel, MD/USA

8:00 - XII-1: Processing and Interpretation of Data From Polarimetric
VIII-7 Weather Radars
DR. DUSAN ZRNIC
DR. N. BALAKRISHNAN
NOAA-ERL-NSSL, Norman, OK/USA

8:30 - XII-2: On the Co-Variance and Mueller Matrix Optimization in
III-2 Radar Polarimetry
DR. SHANE R. CLOUDE
University of Dundee, Dundee, Scotland, UK

9:00 - XII-3: Weibull Radar Clutter Statistics and Applications to
IV-4 Radar Polarimetry
PROF. MATSUO SEKINE
Tokyo Kogyo Daigaku, Nagatsuta Yokohama-Shi, Japan

9:20 - XII-4: On Adaptive Radar Polarimetry: Concepts of Implementation
IV-5 PROF. LEONID B. PREISER
Northrop University, Los Angeles, CA/USA

9:40 - XII-5: Plasma Resonance Effects in Radar Backscattering from
IV-9 Meteor Trails as Studied by the Scattering Matrix Method
DR. P. SAMUEL P. WEI
Boeing Aerospace Co., Seattle, WA/USA

10:00 to 10:30 - **COFFEE BREAK**

SESSION XIII

10:30 to 12:30 - **POLARIMETRIC RADAR METEOROLOGY**
Chairman: DR. WALTER FLOOD
Army Research Office
Research Triangle Park, NC/USA

10:30 - XIII-1: A Critical Assessment of the Historical Development
(Replaced) of Polarimetric Radar Meteorology;
O-5 Where do we come from, where do we go?
PROF. THOMAS A. SELIGA
Pennsylvania State Univ., College Park, PA/USA

11:00 - XIII-2: Dual Polarization Meteorological Radar Developments
VIII-2 at Higher Power Levels
DR. EUGENE A. MUELLER
MR. JERALD D. NESPOR
UIUC/ISWS-CHILL Radar
Champaign, Urbana, IL/USA

11:20 - XIII-3: Polarimetric Radar Application to Meteorology and
VIII-5 Scattering Matrix Measurements
PROF. YAHIA M.M. ANTAR
Royal Military College
Kingston, ONT, Canada

11:40 - XIII-4: FMCW Radar Polarimetry
VIII-3 DR. LEO P. LIGTHART
DR. J.S. VAN SINTTRUYEN
Center for Remote Sensing
Delft University of Technology, Delft, NL

12:10 - XIII-5: **DFVLR Polarimetric Meteorological Instrumentation**
VIII-1 **Radar Facility**
DR.-ING. ARNO SCHROTH
M. CHANDRA
P. MEISCHNER
G. SCHNABL
DFVLR, Remote Sensing Div., Oberpfaffenhofen, FRG

12:30 to 13:45 - **LUNCH BREAK**
(Please, make use of any spare time during Friday noon/afternoon for settling your hotel bills and for preparation of Saturday's Scientific Tour Departure)

SESSION XIV

13:45 to 15:15 - **POLARIMETRIC SIGNATURES IN RADAR METEOROLOGY, OCEANOGRAPHY, AGRICULTURE & FORESTRY**
Chairman: PROF. DR.-ING. ALFONS KESSLER
Technische Hochschule Darmstadt, FRG

13:45 - XIV-1: Polarimetric Radar Measurements in Convective Storms
VIII-8 PROF. VISWA-NATHAN N. BRINGI
V. CHANDRASEKAR
Y. GALESTANI
Colorado State Univ., Fort Collins, CO/USA

14:15 - XIV-2: Towards an Understanding of the Effects of Propagation through Rain on Data from Polarization Diversity Radars
VIII-6
PROF. ANTHONY R. HOLT
University of Essex, Colchester, England, UK

14:45 - XIV-3: Sensitivities of Two Polarimetric Backscattering Models for Sea Ice to Geophysical Parameters
V-10
DR. DALE P. WINEBRENNER
Applied Physics Lab, University of Washington
PROF. LEUNG TSANG
DR. BOHENG WEN
DR. RICHARD WEST
Dept. of Electrical Engr., University of Washington
Seattle, WA/USA

15:15 to 15:45 - **TEA BREAK**

MEETING WDG-4

15:45 to 17:15 - **FINAL WORKING DISCUSSION GROUP MEETING** (Lecture center)
Chairman: MR. LEONARD A. CRAM
THORN-EMI, Wells, Somerset, UK

Submission of Final Reports by Group Reporters
Preparation of Final Overall Statement

SESSION XV

17:15 to 18:15 - **FINAL SESSION**
Chairman: DR. FRÉDÉRIC MOLINET
Soc. Moth, Plessis-Robinson, France

17:15 - Concluding Remarks
LEONARD A. CRAM

17:30 - Instructions on Submission of Final Report Forms
MAJOR DAVID E. STEIN, LTV Aircraft Products Group,
Dallas, TX/USA (now with Westinghouse ESD)

17:45 - Summary of Working Discussion Group Reports
DR. HELMUT SÜSS, DFVLR, Oberpfaffenhofen, FRG

18:00 - Procedures for the Publication of the Workshop Proceedings
PROF. WOLFGANG-M. BOERNER, UIC, Chicago, IL/USA

18:15 - **ADJOURNMENT**

18:00 to 19:00 - **SETTLING OF HOTEL BILLS**
(Please, make use of any spare time during Friday noon/afternoon for settling your hotel bills and for preparation of Saturday's Scientific Tour Departure)

WORKSHOP BANQUET (XVI)

19:00 to 21:00 - **BANQUET**
Hosts: HERR ROLF K. ERLENBACH, Manager, KUK-Hotel Residenz
(Foreword) FRAU JUTTA BROCKHOFF, Vice-Manager, KUK-Hotel Residenz

19:00 TO 20:00 - DINNER

20:15 - INTRODUCTION OF GUESTS OF HONOR
DR. WOLFGANG KEYDEL, DFVLR, Oberpfaffenhofen, FRG

20:30 - THANKS TO THE HOSTS AND THE SPONSORS
IX-7 MR. LEONARD A. CRAM, THORN-EMI, Somerset, UK
DR. TAPAN K. SARKAR, Syracuse University, USA

20:45 - XVI-1: DETAILED INSTRUCTIONS ON THE SCIENTIFIC/CULTURAL TOUR OF SATURDAY VIA ROTHENBURG AND ULM TO OBERPFAFFENHOFEN
DR.-ING. HELMUT SÜSS, DFVLR, Oberpfaffenhofen, FRG
DR.-ING. SIEGFRIED OSTERRIEDER, GHS, Ravensburg, FRG

21:30 - **ADJOURNMENT**

22:00 - **DAY'S END: "Hotel at rest"**

SATURDAY, 24 SEPTEMBER 1988

6:00 - **MORNING CALL**

6:45 to 7:45 - **BREAKFAST**

7:00 TO 8:00 - **SETTLING OF BILLS AND CLEARING OF HOTEL ROOMS**

SCI-CUL-TOUR II

8:15 to 8:30 - CULTURAL/SCIENTIFIC TOUR: ROTHENBURG-ULM-AUGSBURG-OBERPFAFFENHOFEN-MUNICH
Tour Co-Chairmen: DR. WOLFGANG KEYDEL, DFVLR, Oberpfaffenhofen, FRG
(Foreword) DR. HELMUT SÜSS, DFVLR, Oberpfaffenhofen, FRG
DR-ING. SIEGFRIED OSTERRIEDER, GHS, Ravensburg, FRG
PROF. WOLFGANG-M. BOERNER, UIC, Chicago, IL/USA

8:15 - **DEPARTURE** (Note, Luggage of tour participants will be taken along with the tour buses, as advised during registration)

9:00 - **ARRIVAL IN ROTHENBURG** (Visits will include guided sightseeing tour, brief shopping, viewing of St. Jakob Cathedral and City Hall)

10:30 - **DEPARTURE FROM ROTHENBURG** (Ride along new Autobahn to Ulm)

12:00 - **ARRIVAL AT ULM** (Viewing of City Center and ULMER DOM)

12:30 - **DEPARTURE FROM ULM AND DISTRIBUTION OF LUNCH BAGS**
(Note, no lunch break is planned)

14:30 - **ARRIVAL AT DFVLR-OBERPFAFFENHOFEN**

14:30 to 17:30 - **VIEWING OF DFVLR C-BAND DUAL POLARIZATION DOPPLER RADAR FACILITY**

14:45 - WELCOME OF VISITORS AND INTRODUCTION TO THE MISSION OF DFVLR AT OBERPFAFFENHOFEN
PROF. DR. HEINZ HÄBERLE, Director, DFVLR-OPH

15:00 - THE DFVLR-NE-HF MICROWAVE REMOTE SENSING CENTER
DR. WOLFGANG KEYDEL, Director, DFVLR-NE-HF

15:15 - THE DFVLR INSTITUTE OF THE PHYSICS FOR THE ATMOSPHERE, POLARIMETRIC RADAR METEOROLOGY RESEARCH PROGRAM
DR. MANFRED REINHART, Director, DFVLR-IPA

15:30 - GUIDED TOUR THROUGH THE DFVLR DUAL POLARIZATION RADAR METEOROLOGICAL INSTRUMENTATION FACILITY
DR. ARNO SCHROTH, Chief, DFVLR-POL-RAD Research
DR. MADHU CHANDRA, DFVLR-POL-RAD Research

17:00 - FINAL COME TOGETHER AT DFVLR NE-HF LECTURE CENTER
Host: DR. WOLFGANG KEYDEL, DFVLR, Oberpfaffenhofen, FRG

17:15 - FAREWELL SPEECH
IX-8 PROF. WOLFGANG-M. BOERNER, UIC, Chicago, IL/USA

17:30 - **DEPARTURE OF BUS TO MUNICH CENTRAL STATION**

18:30 - **FAREWELL AT MUNICH HAUPTBAHNHOF**

19:00 - **TOUR BUS RETURNS TO BAD WINDSHEIM**
21:45 - **ARRIVAL AT KUK-HOTEL RESIDENZ**

WMB:rf:Nato.2,1.3

HOW TO GET TO CCG AND DFVLR, OBERPFAFFENHOFEN

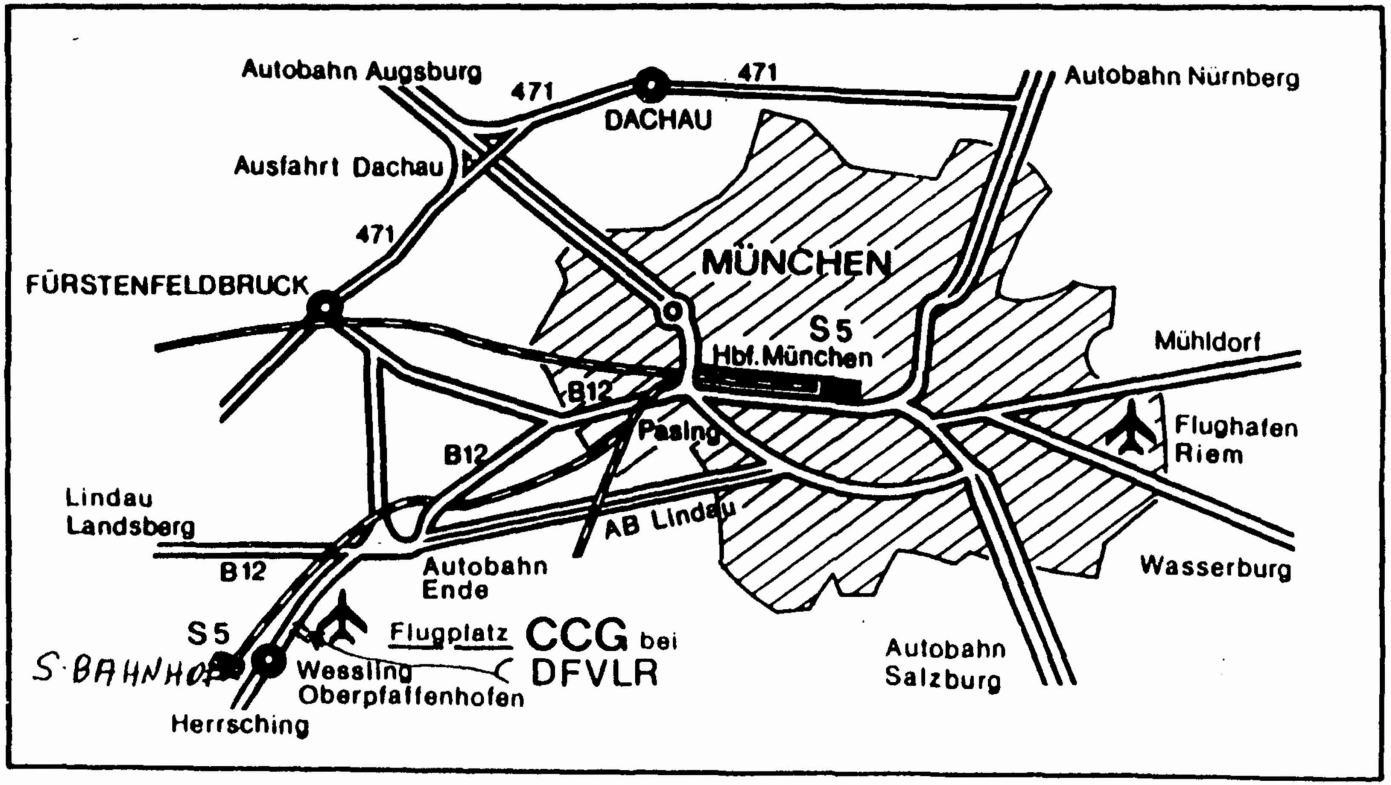
BY AIR: Airport Munich (Riem) - Take Airport-Bus to Main Railroad Station - Take Commuter Train (S-Bahn S5) to "Herrsching" - Leave at "Wessling" (42 minutes from Main Railroad Station to Wessling)

BY TRAIN: From Munich Main Railroad Station take "S-Bahn" (S5) as above

BY CAR: From Wessling you may call CCG (Phone: 28 444) to be picked up - Walking distance is 25 minutes.

If you get lost: Please call 08153 28 444

M A P CCG WESSLING - OBERPFAFFENHOFEN



KUK RESIDENZ HOTEL FINAL INFORMATION ON ARRANGEMENTS
FOR THE

NATO ADVANCED RESEARCH WORKSHOP
ON
DIRECT & INVERSE METHODS IN RADAR POLARIMETRY
18 - 24 September 1988

KUR UND KONGRESSHOTEL RESIDENZ
Erkenbrechtallee 33
D-8532 Bad Windsheim
FRG, WEST GERMANY

Telefon: +[49/0]9841-91-1
Telex: 06 1526 resid d
Telefax: +[49/0]9841-903-15 (temporary)

HOTEL MANAGEMENT

The KUR und KONGRESS (KuK) Hotel Residenz is a known health spa in the European KURORT Bad Windsheim. It is divided into two wings, the KURZENTRUM (spa) and the KONGRESS-ZENTRUM (congress center), which are managed by

Herr Rolf. K. Erlenbach, Manager

Frau Jutta Brockhoff, Vice-Manageress

who welcome you and will provide special assistance if so required.

HOTEL RECEPTION

The personnel behind the hotel reception desk will assist you with matters related to your accommodations, hotel facilities and services, transporation to and from town, and local information.

ARW SECRETARIAT IN ROOM A OF CONFERENCE WING: +[49/0]9841-91-591

The ARW Secretariat will be lodged in Room A across from the Hotel Conference Center. It will be open from 7:30 to 19:30, unless otherwise posted, and it will be staffed by Mrs. Monika Kuehl, HF-Institute, University of Erlangen-Nürnberg; and Mrs. Julie A. Furlong and Brian James of the Communications Laboratory, University of Illinois at Chicago, USA; who will, in turn, be assisted by other members of the ARW. Please consult the Secretariat on matters concerning scheduling, projection needs, reimbursements, special excursions, etc. On Sunday, 1988 Sept. 18, 14:30 to 22:00; and on Friday, 1988 Sept. 23, 14:30 to 22:00; Mr. Reiner Weppner, DFVLR/OPH, will be assisting in the collection of the Workshop payments. The directors of the Workshop are Wolfgang-M. Boerner (Budget, Overall, Editor), Hans Brand and Gerd Schaller (Local Arrangements), Wolfgang Keydel (Budget, Overall), Len Cram (Liaison to Observers), Dag Gjessing (Technical Liaison), Frédéric Molinet (Liaison to Industry), Martin Vogel and Ernst Lüneburg (Co-Editors: Workshop Reports, Budget). They will be glad to assist you in matters for which they are responsible. A special telephone for the entire duration of the Workshop has been set up in the Workshop Secretariat, Room A of the Conference Center, with number 0-9841-91-591 from within FR Germany (or from North America: 011-49-9841-91-591). The main hotel number is 0-9841-91-1 (or from North America: 011-49-9841-91-1).

DUPLICATING FACILITY

A modern duplicating machine has been made available to the ARW-Secretariat and upon request (approval slip must be signed), urgently required papers can be duplicated. However, no excessive use will be permitted.

In addition, we will have access to a Thermo-Fax duplicating machine for producing viewgraph transparencies. All requests for duplicating must be made to

the ARW-Secretariat.

TELEPHONE

Hotels in Germany (and in other European countries) amortize their telephone equipment by adding substantial surcharges to all outgoing phone calls made through the hotel switchboard. If you wish to prevent unpleasant surprises, do not make long distance calls from your room. There are two locations where you can make long distance calls at the official rates: (1) use the coin-operated public phone booth near the reception desk, or (2) place your call from the office in town, a ten minute walk (our suggested procedure).

You can dial the rooms of other participants, but not by dialing their room number. You have to discover the telephone number of each room by calling the hotel reception.

TELEX AND TELEFAX

The hotel possesses its own telex (06 1526 resid d) which may be utilized by the hotel guests. The telefax (+[49/0]9841-903-15) at the editorial office of the local newspaper may be used until the KuK Hotel telefax is installed during the early Fall.

MEDICAL ASSISTANCE

In emergencies, contact the hotel reception. There is a hospital right next to the hotel. Two physicians have regular office hours at the hotel during the week and could see you if your problem can wait. We hope you will all remain healthy.

NOISE ("DAY'S END")

One wing of the hotel is a home for senior citizens. For this reason you are requested to keep down noise levels in the corridors and on the lifts and especially, the volume on the radio and TV in your room, before 7:00 and after 22:00. Note that any group discussions after 22:00 should be carried out in a downtown pub, or in the HOTEL BAR, a cozy basement lounge, which is open until midnight.

BANK

There is a branch (09841-91-558) of the downtown bank, SPARKASSE Bad Windsheim, PASTORIUS Str. 9-11 (09841-90-628), in the hotel. This branch is operated by Mrs. Annemarie Schindhelm and/or Mr. Richard Resch on Mondays, Wednesdays, and Fridays, from 9:00 to 12:00 noon, and from 14:00 to 16:00 on Wednesdays **only**. Please, note that in order to obtain cash, Traveller or Euro-Schecks **only**, are accepted at the branch office. However, at the main downtown bank, cash may be received with plastics, (EUROCARD, MASTERCARD or VISA).

STORE

There exists a small drugstore next to the reception desk, where basic packaged food items, fresh fruits, drinks, incidentals, newspapers, maps, etc., are sold. We will arrange for the daily availability of the Herald Tribune, a shortened overseas version of New York Times.

SWIMMING POOLS*

You have the choice of two free swimming pools heated to 26 or 28 degrees Centigrade, respectively. Both are open from 6:00 to 22:00. The hotel management and some of the more determined permanent residents **insist that all swimmers, male, as well as female, wear caps.** If you did not bring one from home, a shower cap available at nominal cost from the hotel reception will do. You can also swim outdoors at the "Freibad" south of town (see map). Admission is DM 2.50, children DM 1.50.

SAUNA

The sauna is free; however, a reservation at the reception desk is

required.

MEDICAL BATHS

These can be taken on Mondays, Tuesdays and Thursdays in the hotel until 18:00 and on the other days until 16:00. The attendent starts working in the morning at 7:30. More flexible hours might be available at the official Kurpavillon, which has baths run by the city. This is important for those who might wish to combine this NATO-Advanced Research Workshop with a medical cure which could be beneficial to their income tax return (USA/Canada/UK) if not their health.

OTHER RECREATION*

Bicycles can be rented on an hourly basis at the KuK Hotel at DM 5.-/halfday or at the railway station, Monday thru Friday, 7:30 till 18:50; Saturday and Sunday, 7:30 till 12:50, DM 15.- per day.

FISHING is possible near Bad Windsheim. You can get a daily license. Please contact the reception desk.

COACH RIDES* into the surroundings of Bad Windsheim, Thursdays and Sundays 14:00, 15:00, 16:00, and 19:00, from the Kurpark Treffpunkt (see map). Price per person: approximately DM 15.-, depending upon number and distance.

The **MINIGOLF COURSE*** is currently under repair and is not available during August to October, 1988.

TENNIS COURTS* are available in the Kurpark. Price DM 15.- per hour per court. For reservations contact the reception desk.

POOL TABLE and BOWLING ALLEY* are available in the hotel. Inquire about rates.

TABLE TENNIS is free. You can obtain paddles and balls at the reception desk against a deposit of DM 10.-.

HOTEL BAR opens at 20:00 daily. (Any group discussions after 22:00 should be carried out in the cozy basement lounge).

MORNING CALL

All participants will receive a **wake-up call at 6:00 in the early morning** so that breakfast meetings may start punctually at 7:00.

MEALS

Breakfast is served between 7:00 and 8:00 in the Residenzsaal. Late risers can take their breakfast until 10:30 in the cafeteria. Breakfast is buffet style. There is an ample selection of rolls, meats, cheeses, etc. But note that for juice or eggs for breakfast, you will have to pay extra.

Luncheon will be at 12:30, immediately following the morning sessions.

Dinner is at 18:15. The two main meals: Lunch (Mittagstisch) and Supper (dinner: Abendessen) will be taken in the Resturant "Die Brücke". Please sit at the tables reserved for the ARW. Coffee after dinner is extra. Other beverages during either main meal are extra as well. It is not feasible to have these extra beverage expenses charged to your room. Please pay the waiter directly. The local draft beer Bürgerbräu is remarkable in taste -- try it; and more so is the spicy Frankenwein -- don't miss it!

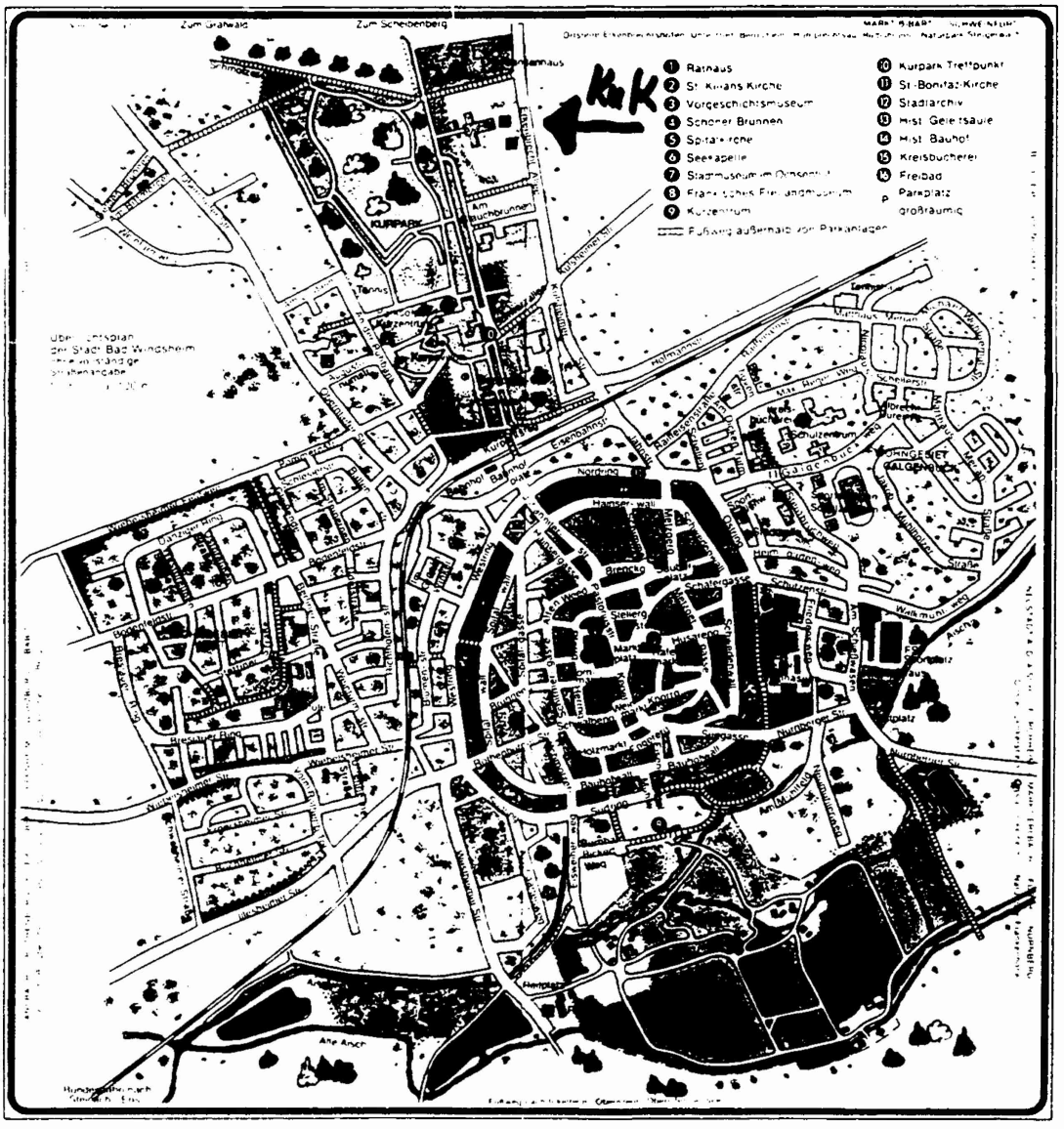
For each main meal there will be three choices. Of those three choices, one choice is vegetarian and one choice is non-pork. The menu will be displayed outside the main lecture hall one day in advance, each menu labeled with a different color. Corresponding color-coded tickets are provided. You are requested to pick tickets (one for lunch and one for supper) corresponding to your choices one day ahead, after supper, so that the cook knows what and how

much to prepare. This system, which may appear complicated, has worked very well with previous NATO conferences here; and, engineering scientists are surely as able to cope with this as were the mathematicians, physicists, linguists and taxonomists who came here in previous years. Usually, one of the menus at each meal avoids pork. Vegetarians can request a special menu well in advance. **Any other special diet requested for medical reasons may require your financial support and should be negotiated, in detail, prior to the Workshop (see Questionnaire).**

MINIBAR

Each room has a refrigerated minibar containing numerous delectables. If you remove anything, it must be marked on the yellow slip provided, so that you may be billed for it separately (not included in negotiated hotel room charge: PLEASE, pay before departing!).

* Quoted charges applied in 1987 and are subject to changes during 1988.



MAP OF BAD WINDSHEIM WITH KUK HOTEL

FINAL INFORMATION ON WORKING GROUP DISCUSSION PROGRAMS,
LIST OF WORKING GROUPS, PARTICIPANTS, AND INSTRUCTIONS ON REPORTING

(to be supplemented with additional instructions)

NATO-Advanced Research Workshop
on
Direct and Inverse Methods in Radar Polarimetry

KuK Hotel Residenz, Bad Windsheim, FR Germany
18 September to 24 September 1988

(1988 September 15)

INTERACTION OF WORKING GROUP PARTICIPANTS

The overall objectives of this NATO-Advanced Research Workshop will require the concentrated interaction of a great many experts in several fields of electromagnetic imaging and remote sensing. Therefore, from the outset of organizing this ARW, we intended to invite a wide body of researchers of international reputation. All of you have been assigned a multitude of functions as speakers, session chairmen, working group coordinators, moderators or reporters and/or as members of various committees. The time schedule has been arranged so that optimal interaction among the various participants is possible. There are no simultaneous lectures scheduled; the scheduling of the six working discussion groups which take place simultaneously in separated discussion pens, has been arranged such that active interaction among the various groups is feasible and the exchange of ideas among the working discussion groups is strongly promoted. **NOTE: We request that every speaker presenting a paper use the last three minutes of his presentation to identify important, unresolved questions which could be the subject for working group discussions.**

Again, we reiterate that the main purpose of this NATO-Advanced Research Workshop is to provide a FORUM in which international experts can expand interaction and enlarge the scope of their activities in the pursuit of promoting this rapidly growing, new, engineering science discipline of "Inverse Methods in Electromagnetic Imaging," and, in particular, advance direct and inverse methods applied to "High Resolution Polarimetric Radar Imaging." We wish to ensure that participants from all NATO-member and allied countries will be interacting actively and that this Workshop will provide you with an opportunity for future research interaction by applying to various existing and/or new programs of the NATO Scientific Affairs Division which will be described to you in detail by Dr. Tilo Kester, Dr. Craig Sinclair of the NATO Scientific Affairs Division, Brussels, Belgium, or their designated representative.

SUMMARY OF SPECIFIC WORKSHOP OBJECTIVES & RESEARCH BACKGROUND

This is the second ARW in the field of electromagnetic imaging, radar remote sensing, and target versus clutter discrimination. During our last ARW (in 1983), we assessed the inverse methods in electromagnetic imaging primarily for solving radar scattering problems, including, mathematical and numerical inversion techniques, and signal and image processing, with the specific emphasis on the vector (polarization) nature of electromagnetic fields. The resulting two-volume Proceedings are highly praised in the international literature (see attachment) and stimulating letters from previous participants and many other readers of the resulting Proceedings encouraged us to organize another ARW on a more specific topic.

Inverse methods have become a fundamental tool in the physical sciences for remotely sensing unknown objects and reconstructing their physical properties. Significant technological advances during the last few years in the field of electromagnetic probing in the m to sub-mm wave, infrared and optical regions, as well as of data processing and mathematical inverse methods opened up new

avenues with regard to detection, identification and imaging of natural and manmade objects and gaseous agents in our environment. Information previously considered irretrievable can now be recovered from noise and clutter disturbed data by use of more advanced electromagnetic imaging techniques incorporating inverse methods.

This time we wish to concentrate on direct and inverse methods **exclusively** related to radar polarimetry (including every single presentation). High resolution radar polarimetry has most recently become an indispensible tool in modern electromagnetic sensor technology, both in the civil and military sectors, as well as in remote sensing and radar meteorology. From the outset, we wish to emphasize that by incorporating coherent polarimetric phase information into radar signal and image processing, one can anticipate a breakthrough which is at least comparable to that brought about by the advent of holography and computer assisted tomography and its applications to Synthetic Aperture Radar (SAR) and Inverse Synthetic Aperture Radar (ISAR). Although considerable R&D efforts have already been expanded during the past three decades, there still exist many "grey areas" in both theory and techniques of radar polarimetry which we wish to illuminate during the prospective ARW covering the meter-to -sub-millimeter wavelength, infrared, and also optical regions of the electromagnetic spectrum. The emphasis will be placed on the basic principles of electromagnetic wave interrogation with natural and/or manmade media and objects, the optimal structuring of illumination and detection, optimal recovery of useful target signal, mathematical and data processing methods, and representative applications.

NATO-ARW-DIMRP '88 BOOKSHELF

We invite all participants of this workshop, who have published pertinent treatises, monographs, text and/or research books to make available one copy for display at our NATO-ARW-DIMRP '88 Bookshelf during the entire workshop. It would be appreciated if order forms and information about the publishing company could also be made available (see Special Questionnaire: NATO-ARW-DIMRP '88 Bookshelf Contributions).

SELECTION OF WORKING DISCUSSION GROUP TOPICS

The working discussion groups are to work on isolating unresolved problems and providing recommendations for potential future research projects which will require active interaction of engineering scientists of all NATO-member countries. The five questions (W-1 to W-5) chosen define issues for which immediate answers are required. The composition of the chosen speakers, senior research scientists/engineers is well suited to tackle these problems and we do expect clear-cut resolutions and recommendations for additional near-future NATO Advanced Study Institutes and/or NATO Advanced Research Workshops (see special material to be distributed during the workshop registration on September 18, 1988).

We have also scheduled a formal Working Discussion Group (W-6) for research management representations of various research funding organizations of active NATO-member countries for the purpose of generating future close interaction and sponsorship of large-scale international research projects.

WORKING DISCUSSION GROUP TOPICS WITH BRIEF DESCRIPTIONS

(for detailed descriptions of Workshops see "Brief Workshop Description", Workshop Section, outlined in the First Announcement previously forwarded to you)

W-1: ASSESSMENT OF LITERATURE ON POLARIMETRIC THEORY & APPLICATIONS

W-2: POLARIMETRIC TARGET AND CLUTTER ANALYSES: (DIRECT SCATTERING)

W-3: POLARIZATION DIFFRACTION TOMOGRAPHY: SENSING OF CONCEALED OBJECTS

(VECTOR INVERSE PROBLEM)

W-4: UNIFICATION OF NOMENCLATURE, CONVENTIONS & STANDARDS IN POL-RAD/SAR/ISAR IMAGING

W-5: PROCESSING, FORMATTING & CALIBRATION OF POL-RAD/SAR/ISAR MEASUREMENTS

W-6: ACCELERATION OF INT'L/NATO INTERACTION: DESIGN OF INT-NATO POL-RAD/SAR MEASUREMENT CAMPAIGNS (ADMINISTRATIVE)

Please, note that the topics may still be altered slightly and recommendations for changes are welcome.

SCHEDULING AND ORGANIZATION OF WORKING DISCUSSION GROUP MEETINGS

All of the six working discussion groups will meet during the late afternoon slot from 16:00 to 17:45 on Monday, Tuesday, Thursday and Friday. During the Monday meeting all groups will first meet together to be given advice on the instructions provided to them (see "Technical Program Outline"), and will then separate into the six working discussion groups defined above, meeting in six separate discussion pens (Rms. B to G of the Conference Center), which will be identified by working discussion group numbers W-1 to W-6 and whose locations will be the same throughout the NATO-Advanced Research Workshop and will be made known to you in the packets received during registration. The discussion groups will meet separately on Tuesday, Thursday and on Friday from 16:00 to 16:40, then from 16:45 to 17:45 jointly for reporting the main recommendations to all participants.

A chairman, whose functions are defined below, is assigned only for the joint meetings of Monday and Friday. Each working discussion group is assigned a coordinator, a moderator, an advisor and a reporter, whose functions are defined below. In addition, each working discussion group is assigned approximately seven (7) to fifteen (15) working members, all of whom are considered experts in the specific topics to be discussed. Therefore, there may be some NATO-Advanced Research Workshop participants who have not been assigned to a specific working discussion group because we consider their expertise to be of great assistance, not only to one specific group, but to the working group activities of more groups and we invite them to rotate and to provide cross-talk among the eight technical and one administrative groups.

All questions pertaining to the working discussion group activities should be directed to members of the planning and executive committee, one of which will be available at most times at the ARW Secretariat in Room A of the Conference Center.

SUGGESTED DUTIES OF WORKING DISCUSSION GROUP CHAIRMEN, COORDINATORS, MODERATORS, ADVISORS, REPORTERS, CO-EDITORS AND WORKING MEMBERS (Suggested guidelines by W-M. Boerner)

Chairmen: Chairmen will carry out the same duties as a chairman of a paper session, which includes:

(i) introduction of speakers and topics;

(ii) assuring that alloted time is strictly adhered to;

(iii) coordination of questions and answers.

Coordinators: Coordinators assure that:

(i) the discussion group pens are set-up properly;

(ii) all members assigned to a working group have been

introduced to one another;

(iii) all workshop information available at the workshop hotel can be easily accessed.

Moderators: Moderators are chosen on the basis of their leadership potential in their field of expertise and their duties include assuring dynamic interaction of working group members by:

(i) stimulating discussion so that objectives of the topics to be discussed can be met;

(ii) closely interacting with the group coordinator.

Advisors: Advisors are chosen on the basis of their accredited senior leadership roles, as well as for their past NATO-ASI/ARW experience. The main duties are to:

(i) assure efficient and effective group discussion interaction;

(ii) closely work with the group reporter.

Reporters: Reporters are to collect all question statements, written notes, discussion results, i.e., act as the recorder of discussions. The main duties are to:

(i) streamline discussion results and direct the writing and reporting proceedings for the intermediate, final draft, and print-ready group discussion reports which are limited to about five to eight pages each;

(ii) closely work with both the Advisor and the Co-Editors on the final individual group reports and the overall summary of discussion group activities.

Co-Editors: The Co-Editors, along with the reporters will prepare the print-ready final reports for Part VII: Working Group Reports of the Proceedings of this NATO-ARW on Direct and Inverse Methods in Radar Polarimetry.

Working Members: The success of working discussion groups depends on the positive collaboration of its members. Members of a group are its working engineering scientists who will assist us in finding answers to unresolved questions now and in the future. Most of the members of the working groups W-1 to W-5 will have presented papers during the regular paper presentation session; whereas those of W-6 are chosen on the basis of their national NATO country management leadership. Most of the members selected for a particular working discussion group have either read each other's papers or, most likely, have met before. Discussion group members should immediately get together upon arrival at the workshop hotel and prepare succinct questions pertaining to the specific questions assigned to their group as suggested below. All discussion group members are to interact strongly with their member participants and from a FORUM for expert scientific discussions.

SUGGESTED PRE-WORKSHOP PREPARATIONS FOR WORKING DISCUSSION GROUP ACTIVITY

Recalling our perception of considering every scientific participant (speaker and/or observor) an expert, it should not take too much effort for anyone to collect their thoughts and to prepare a short list of very timely, pertinent, unanswered questions which requires an immediate resolution and integrate them

into their research paper for summary during the last three minutes of presentation.

We should like to suggest that all of you complete the questionnaire for the working discussion group activities, PROPOSAL FOR QUESTIONS SHEET, on all specific topics (W-1 to W-6) for which you consider yourself an expert, and especially, for the topic you have been assigned to contribute as worker, reporter, coordinator, etc. You may wish to add or copy any relevant material that could serve as useful input for the working discussion group activities.

You should retain the original(s) for yourself, produce one copy each to be handed in upon arrival in the specific box designated as "QUESTIONS FOR W-", and return another copy by 1988 Sept. 1 to the KuK Hotel. These Proposal for Questions Sheets will then be duplicated and handed out during the MONDAY working discussion group meeting, after the general introduction, once you have separated into your specific working discussion groups.

We will also like to suggest that you be prepared to support your proposed questions by documented results for which you should prepare overhead viewgraphs (preferably no slides) which can be presented during the working group meetings if so requested by the group.

It is of great use to all NATO-ARW participants, and particularly to members of specific working discussion groups if you could provide a list of "Most Recent Important Publications on the Subject Matter of W-". Furthermore, if you should be the author or co-author of a pertinent monograph, book, treatise, please, be so kind to take two display copies along, one for your use and the other for our NATO-ARW-DIMRP'88 BOOKSHELF.

In conclusion, we would like to re-emphasize that it is important that you prepare the concluding remarks of your paper presentation during the paper presentation sessions such that it addresses the very specific questions you wish to propose for scientific deliberation during your working discussion group meetings.

SPECIFIC SUGGESTIONS FOR WORKING DISCUSSION GROUP INTERACTIONS

(to be distributed during registration and during the first meeting together with returned duplicated "QUESTIONS FOR W-Sheets")

Please, carefully study the TECHNICAL PROGRAM OUTLINES which contain all information on the scheduling of the working discussion group interactions.

LIST OF WORKING DISCUSSION GROUP PARTICIPANTS AND COORDINATION COMMITTEES

(Please, note your name may appear as a contributing working member for one or more working discussion groups: W-1 to W-6. Please, inform us by Sept. 1, 1988 or at the latest on your arrival about any reappointments you prefer.)

PLANNING COMMITTEE

Co-Chairmen:	L.A. Cram and W-M. Boerner
Chief Coordinators:	A. Schroth and W.A. Holm
Chief Moderators:	T.K. Sarkar and W. Wiesbeck
Chief Advisors:	D.T. Gjessing and F. Molinet
Chief Reporters:	S. Cloude and H. Süss
Co-Editors:	A. Blanchard and D. Stein
(Final Reports):	S.K. Chaudhuri and K.J. Langenberg
Secretariat Assts:	K-H. Bethke, B.D. James, F-N. Kong, M. Borgeaud

W-1: ASSESSMENT OF LITERATURE ON POLARIMETRIC THEORY & APPLICATIONS

Coordinators: G. Wanielik and F. Molinet
Moderators: H. Mott and G. Können
Advisors: J.R. Huynen and W. Wiesbeck
Reporters: K. Itoh and S.P. Wei

Working Members:

H. Blok	J.P. Hansen	L.P. Ligthart	K. Stiefvater
W-M. Boerner	H. Hellsten	J.P. Marcellin	T. Suzuki
Z. M. Czyz	W.A. Holm	E.A. Mueller	J.J. van Zyl
J.L. Eaves	A.R. Holt	L.B. Preiser	G. Wanielik
A. Farina	J.R. Huynen	L.W. Root	S.P. Wei
M. Feinstein	A. Kessler	A. Schroth	W. Wiesbeck
R.H. Giles	F.N. Kong	M. Sekine	D.P. Winebrenner
D. Giuli	A.B. Kostinski	T.A. Seliga	
D.T. Gjessing		D. Solimini	

W-2: POLARIMETRIC TARGET AND CLUTTER ANALYSES: (DIRECT SCATTERING)

Coordinators: A. Rossettini and Y.M.M. Antar
Moderators: L.W. Root and A. Britton
Advisors: R.H. Giles and H. Chaloupka
Reporters: D.E. Stein and R. Hammel

Working Members:

Y.M.M. Antar	S.K. Chaudhuri	J.P. Hansen	R. Popp
D. Baur	S.R. Cloude	W.A. Holm	S. Riegger
A. Blanchard	G. Crisp	P. Hoogeboom	B. Röde
W-M. Boerner	P. Dubois	R. Hüppi	H. Süss
M. Borgeaud	J.L. Eaves	J.R. Huynen	J.J. van Zyl
H. Brenner	W.K. Flood	A. Kessler	G. Wanielik
V.N. Bringi	D. Giuli	A.B. Kostinski	W. Wiesbeck
A. Britton	D.T. Gjessing	A.P. Ligthart	P. Winebrenner

W-3: POLARIZATION DIFFRACTION TOMOGRAPHY: SENSING OF CONCEALED OBJECTS

Coordinators: H. Blok and H. Hellsten
Moderators: D. Lesselier and J. Detlefsen
Advisors: K.J. Langenberg and H. Ermert
Reporters: M. Vester and M. Borgeaud

Working Members:

A. Blanchard	R. Grosskopf	T.K. Sarkar	J.J. van Zyl
H. Blok	T. Gurke	G. Schaller	M. Vester
W-M. Boerner	H. Hellsten	D.R. Sheen	S.P. Wei
H. Chaloupka	P. Hoogeboom	H. Süss	W. Wiesbeck
S.K. Chaudhuri	B.D. James	T. Suzuki	D.P. Winebrenner
P. Dubois	G.N. Jepps		D.S. Zrnic
J.L. Eaves	A. Lohmann		
W.K. Flood	K. Magura		

W-4: UNIFICATION OF NOMENCLATURE, CONVENTIONS & STANDARDS IN POL-RAD/SAR/ISAR IMAGING

Coordinators: A. Blanchard and D. Stock
Moderators: G. Crisp and S.R. Cloude
Advisors: V.N. Bringi and A. Schroth
Reporters: A.B. Kostinski and M.R. Feinstein

Working Members:

A. Blanchard	Z.M. Czyz	J. Jepps	J. Poiares-Baptista
E. Baur	P. Dubois	A. Kessler	R. Popp
W-M. Boerner	J.L. Eaves	W.A. Keydel	B. Röde
H. Brand	A. Farina	J.A. Kong	A.W. Root
V.N. Bringi	W.K. Flood	G.P. Können	A. Schroth
A. Britton	D. Giuli	L.P. Ligthart	D.R. Sheen
L.A. Cram	D.T. Gjessing	J.P. Marcellin	K.C. Stiefvater
G. Crisp	J.P. Hansen	F.A. Molinet	T. Suzuki
	J.R. Huynen	H. Mott	K.C. van Sinttruyen
	K. Itoh	E.A. Mueller	W. Wiesbeck
			D.S. Zrnic

W-5: PROCESSING, FORMATTING & CALIBRATION OF POL-RAD/SAR/ISAR MEASUREMENTS

Coordinators: J. van Zyl and G.A. Mueller
Moderators: D. Zrnic and D.R. Sheen
Advisors: D. Giuli and P. Dubois
Reporters: L. Ligthart and T. Suzuki

Working Members:

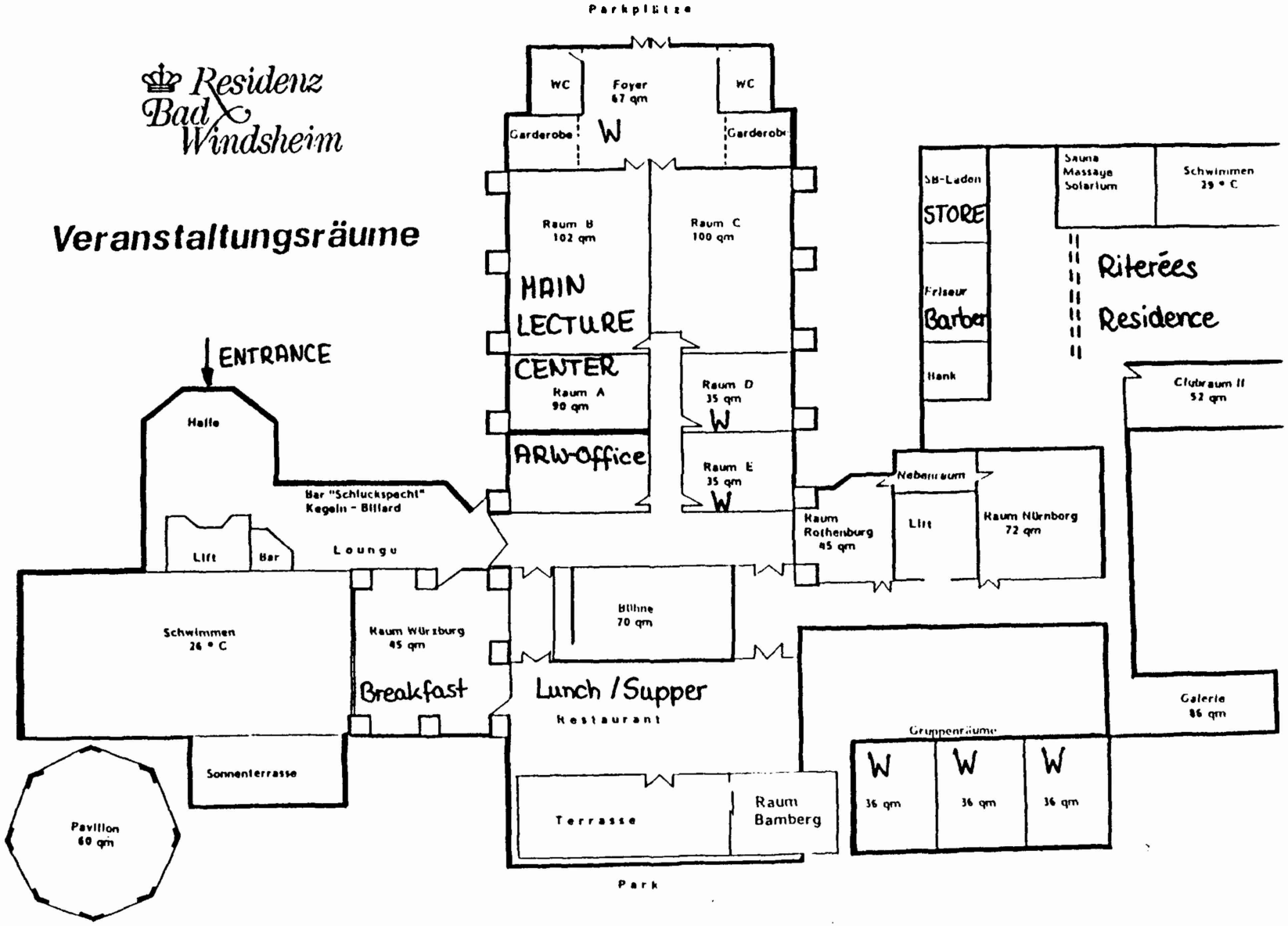
Y.M.M. Antar	P. Dubois	B.D. James	T.A. Seliga
A. Blanchard	J.L. Eaves	J. Jepps	A. Sieber
V.N. Bringi	M. Feinstein	W. Keydel	K.C. Stiefvater
A. Britton	W.K. Flood	J.P. Marcellin	J.R.D. Stock
S.K. Chaudhuri	M. Gherardelli	J. Poiares-Baptista	H. Süss
S.R. Cloude	D.T. Gjessing	S. Riegger	T. Suzuki
L.A. Cram	J.P. Hansen	B. Röde	J.S. van Sinttruyen
Z.M. Czyz	H. Hellsten	A.W. Root	W. Wiesbeck
	W.A. Holm	A. Schroth	
	P. Hoogeboom		
	K. Itoh		

W-6: ACCELERATION OF INT'L/NATO INTERACTION: DESIGN OF INT-NATO POL-RAD/SAR MEASUREMENT CAMPAIGNS (ADMINISTRATIVE)

Coordinators: J.G. Smith and J.L. Eaves
Moderators: T.A. Seliga and A. Sieber
Advisors: W. Keydel and D. Gjessing
Reporters: W. K. Flood and R. Hüppi

Working Members:

W-M. Boerner	J.P. Hansen	L.W. Root	J.J. van Zyl
V.N. Bringi	W.A. Holm	A. Schroth	S.P. Wei
A. Britton	P. Hoogeboom	D.R. Sheen	D.S. Zrnic
L.A. Cram	L.P. Ligthart	D.E. Stein	
D.T. Gjessing	E. Moshang	H. Süss	
	E.A. Mueller		


Residenz
Bad
Windsheim
Veranstaltungsräume
Parkplätze
WC
Foyer
67 qm
WC
Garderobe
W
Garderobe
Raum B
102 qm
Raum C
100 qm
MAIN
LECTURE
CENTER
Raum A
90 qm
Raum D
35 qm
W
ARW-Office
Raum E
35 qm
W
ENTRANCE
Halle
Bar "Schluckspecht"
Kegeln - Billard
Lift
Bar
Lounge
Schwimmen
26 ° C
Raum Würzburg
45 qm
Breakfast
Billine
70 qm
Lunch / Supper
Restaurant
Sonnenterrasse
Pavillon
60 qm
Terrasse
Raum
Bamberg
Park
SB-Laden
STORE
Friseur
Barber
Bank
Sauna
Massage
Solarium
Schwimmen
29 ° C
Riterées
Residence
Clubraum II
52 qm
Nebenraum
Raum
Rothenburg
45 qm
Lift
Raum Nürnborg
72 qm
Gruppenräume
W
36 qm
W
36 qm
W
36 qm
Galerie
86 qm

SPOUSES AND CULTURAL PROGRAM

NATO-ARW-DIMRP '88
on
DIRECT & INVERSE METHODS IN RADAR POLARIMETRY

Kur und Kongress-hotel Residenz
Bad Windsheim, FRG, September 18-24, 1988

(1988 June 30)

Official Language: ENGLISH

Bad Windsheim was one of the Emperial Cities (REICHSSTADT) of medieval Germany and its famous city hall, city museum and churches are still existing historical sites, and in addition the KURPARK and the Franconian Open-Air Museum are available for extensive sight-seeing within the charming town. It is located in Franconia, a part of Germany full of historical sites and culture in a lovely landscape. Famous and beautiful old towns are close by like NÜRNBERG, ANSBACH, BAMBERG and WÜRZBURG, as well as the 'romantic road' in the Taubervalley with ROTHENBURG, a unique medieval town, and further south DINKELSBÜHL, another historical center along the ROMANTISCHE STRASSE. Last but not least, Bad Windsheim is situated at the southern border of the well-known Franconian wineries-region, inviting to all visitors.

It was the aim of the planning committee to make available tours and cultural events for our participants and particularly the accompanying spouses to visit and view these famous Franconian cultural and historical sites.

SUNDAY, Sept. 18, 1988

Arrival and Opening Session
(no other programs are planned)

MONDAY, Sept. 19, 1988

No day-time events are planned. We suggest to relax and to view Bad Windsheim on your own.

Evening Program (for all participants)

18:40 to 20:00	Official Sight-Seeing Walk of down-town Bad Windsheim
21:10 to 21:00	Reception by the First Mayor at the "Historische Rathaussaal"

TUESDAY, Sept. 20, 1988

TOUR I*: NÜRNBERG

(Tentative: Arrangements depend upon final number of tour participants)

9:00	Departure	Kurhotel Residenz
10:15	Arrival	Nürnberg - Burg
10:30 to 15:30		Viewing of Burg, Dürer Haus, St. Sebald, Marktplatz, Frauen-Kirche, St. Lorenz Cathedral
15:30 to 18:30		Germanisches National Museum
19:00 to 20:15		Supper at Heiling-Geist-Spital
20:15 to 20:45		Nightviewing of Nürnberg Castle
20:45	Departure	
21:45	Arrival	Kurhotel Residenz

WEDNESDAY, Sept. 21 1988

TOUR II*: ROTHENBURG, ANSBACH, DINKELSBüHL

(Tentative: Arrangements depend upon final number of tour participants)

8:30	Departure:	Kurhotel Residenz
9:10 to 11:00		Rothenburg: City hall and sightseeing of city
12:00 to 13:00		Lunch in Ansbach
13:00 to 16:00		Ansbach: Viewing of Roccoco Castle
16:00 to 18:45		Guided Tour of Dinkelsbühl, Visits of the "Bayerische Landesgartenschau 1988", and of the Gothic Cathedral
19:00 to 20:30		Supper together with all participants at the famous Franconian Restaurant "DIE SCHRANNE" in a medieval crop barn at the Weinmarkt in Dinkelsbühl
20:45	Departure	Dinkelsbühl to Bad Windsheim by Tour Bus
21:30	Arrival	KuK Hotel Residenz

THURSDAY, Sept. 22, 1988

TOUR III*: BAMBERG, VIERZEHNHEILIGEN, LICHTENSTEIN

(Tentative: Arrangements depend upon final number of tour participants)

8:15	Departure:	Kurhotel Residenz Bustour through Franconian wineries' region KITZINGEN - VOLKACH - BAMBERG (Viewing of city) Schloß BANZ (viewing and lunch) - Vierzehnheiligen (viewing of baroque shrine) - via WÜRGAU through "Franconian Switzerland"
17:15	Arrival	Kurhotel Residenz

Evening Events (for all participants)

17:45 to 21:30		Visit of the Franconian Open-Air Museum with Carp Dinner (Karpfenessen)
17:45	Departure	Kurhotel Residenz
17:45 to 20:00		Viewing of Museum
20:00 to 21:15		Karpfenessen with Entertainment by the Windsheim Sänger
21:30	Arrival	Kurhotel Residenz

FRIDAY, Sept. 23, 1988

No day-time events are planned. Transportation to and from Rothenburg can be made available upon early request.

Evening Event (for all participants): Workshop Banquet

19:00 to 20:00	Festive Dinner in the RESIDENZ SAAL
20:00 to 21:30	Final Program

SATURDAY, Sept. 24, 1988

8:15	**Departure of all participants from the Kurhotel Residenz**
8:15 to 18:30	Scientific Cultural Tour for all participants as described in the TECHNICAL PROGRAM OUTLINES, TPO, Page 15

*NOTE, Final decission on these Tours (I, II, III) will have to be made by Monday, Sept. 19, 1988, 10:00 am. Exact costs depend on the number of participants and are not available at this time. Please, as instructed, forward questinonaires by 1988 Sept. 1.
A tour guide for each tour chosen to take place according to above suggestions, will be appointed by Monday, Sept. 19, 1988, 10:00 am.

PRIVATE TOUR ARRANGEMENTS

Any additional private tour arrangements may be made with the assistance of

Reisebüro - Omnibusverkehr
Wilhelm Thürauf
Johanniterstraße 27

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+[49/0]-984-3108

Please, make use of the tourist center for additional information at the

Verkehrsamt
Rathaus am Marktplatz
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SUGGESTIONS FOR SHOPPING

We suggest that you make use of Tours I and II for shopping either in Rothenburg and/or Nürnberg, both being famous for their selections of objects and apparel.

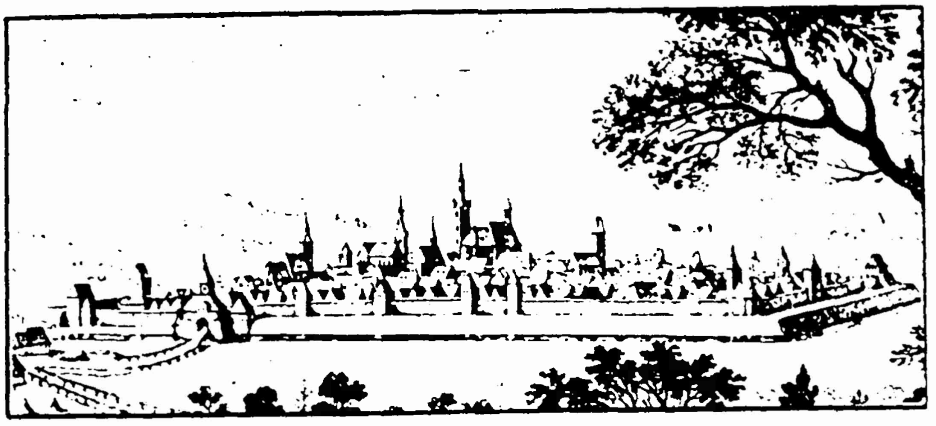
CLIMATE AND SUGGESTED APPAREL

Usually, the month of September is one of the most lovely for Central Frankonia -- sporting blue skies with crisp to moderately warm temperatures. Therefore, we suggest that you consider flexibility in the selection of your wearing apparel, i.e., be prepared for warm, sunny middays and cool, brisk evenings. If you plan to travel before or after the workshop anywhere in coastal, North-Central Europe, please note that it may be cold, damp and rainy.

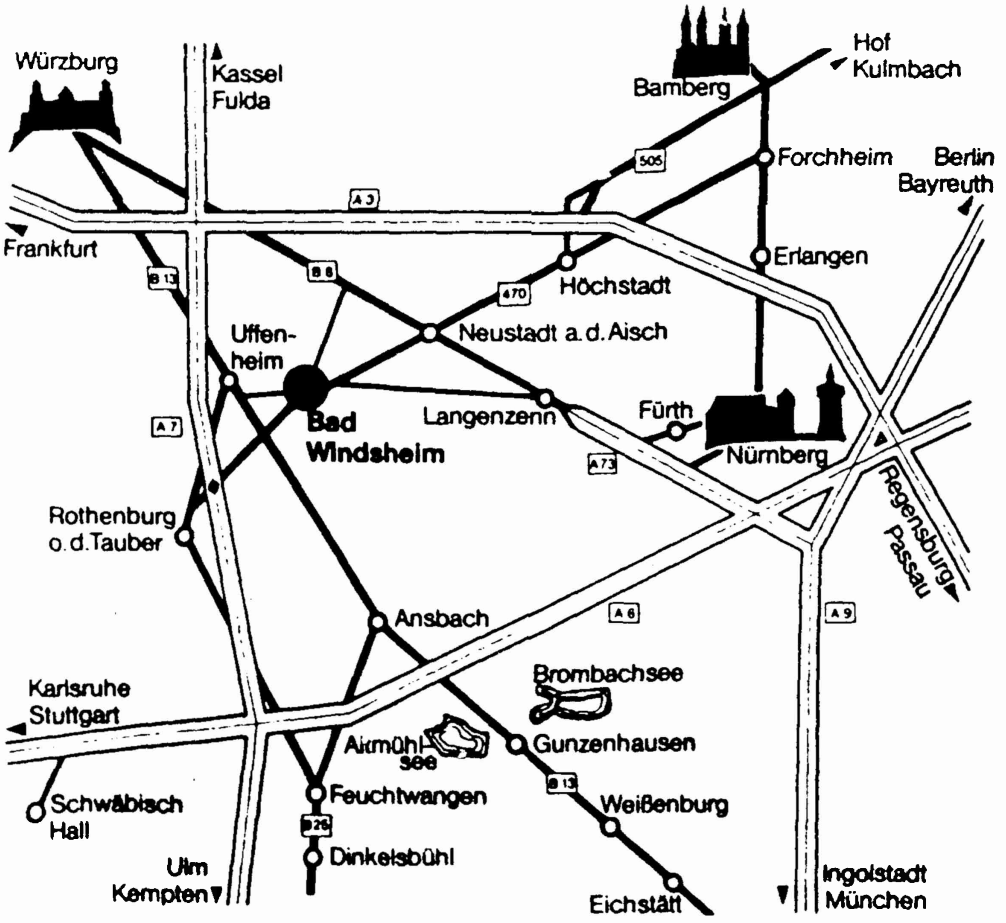
It is no longer customary to wear long, dark dresses during formal and festive events. It is now acceptable to be comfortably well-dressed at these gatherings (semi-formal).

COMPLETE QUESTIONNAIRES AND MAIL BACK WITH 1988 SEPT. 01 RETURNS TO KuK Hotel Residenz, Bad Windsheim, FRG.

Prepared by: Prof. Wolfgang-M. Boerner



Die Reichsstadt Windsheim, um 1644 (Merian-Stich, Ausschnitt).



Highway and Autobahn routes to Bad Windsheim (Sept. 1988)

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for

Parts 1 & 2

WMB:rf:NATO.1,1.12

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TOPIC IX - FINAL REPORTING OF WORKING DISCUSSION GROUP ACTIVITIES

During this second ARW, procedures developed during the NATO-ARW-IMEI '83 were followed closely, and we refer to its Proceedings, Second Part, last Section VI, FINAL REPORTS OF WORKING DISCUSSION GROUPS, pp 1267-1298, for comparison.

IX-0 BACKGROUND

During NATO-ARWs, working discussion groups are assigned to work on isolating unresolved problems and on providing recommendations for potential future research projects which will require active interaction of engineering scientists of all NATO-member and allied countries of Austral-Asia and the NW Pacific Rim. The five topics (**W-A** to **W-E**) chosen define issues for which immediate answers are required. A very detailed instruction package was forwarded to each participant providing also the assignments for the chosen speakers, senior research scientists/engineers/administrators for each group together with recommendations for pre-workshop preparations so that we were to expect clear-cut resolutions and recommendations for additional near-future NATO-ASIs and/or NATO-ARWs. Interaction and active cross-talk among the group activities was strongly encouraged (see lists). Also, this time, we have scheduled a formal Working Discussion group (**W-F**) for research management representation of various funding organizations of active NATO-member countries for the purpose of generating future close interaction and sponsorship of medium and large scale international research projects. Section **IX-7** contains concluding remarks by participants on the present NATO-ARW-DIMRP'88 event; currently, a very profound effort is now also being initiated for the planning of the third ARW scheduled for 1993 September 19-25 on "Wideband Polarimetric Doppler Radar Sensing & Imaging" as summarized in the final Section **IX-8**.

WORKING DISCUSSION GROUP TOPICS WITH BRIEF DESCRIPTIONS

IX-1 ASSESSMENT OF LITERATURE OF POLARIMETRIC THEORY & APPLICATIONS (NATO-ARW-DIMRP'88 BOOKSHELF): **(W-A)**

IX-2 CHARACTERIZATION OF SCATTERING SURFACES AND MEDIA: **(W-B)**

IX-3 INVERSE SCATTERING WITH SPECIAL ATTENTION TOWARDS IMAGING: **(W-C)**

IX-4 PROCESSING, FORMATTING AND CALIBRATION OF POL-RAD/SAR/ISAR MEASUREMENTS: **(W-D)**

IX-5 UNIFICATION OF NOMENCLATURE, CONVENTIONS AND STANDARDS FOR POL-RAD/SAR/ISAR/IMAGING: **(W-E)**

IX-6 ACCELERATION OF INTERNATIONAL/NATO INTERACTION DESIGN OF INTERNATIONAL-NATO POL-RAD/SAR/ISAR MEASUREMENT CAMPAIGNS (ADMINISTRATIVE): **(W-F)**

SUGGESTED DUTIES OF WORKING DISCUSSION GROUP CHAIRMEN, COORDINATORS, MODERATORS, ADVISORS, REPORTERS AND WORKING MEMBERS
(Suggested guidelines by W-M. Boerner)

Chairman: Will carry out the same duties as a chairman of a paper session which include:

(i) introduction of speakers and topics;

(ii) making sure that alloted time is strictly adhered to;

(iii) coordination of questions and answers.

Coordinators: Responsibilities include making sure that:

(i) the discussion group pens are set-up properly;

(ii) all members assigned to a working group have been introduced to one another;

(iii) all workshop information available at the hotel's workshop office can be easily accessed.

Moderators: Moderators are chosen on the basis of their leadership potential in their field of expertise. Duties are to assure dynamic interaction of working group members by:

(i) stimulating discussions so that objectives of the topics to be discussed can be met;

(ii) closely interacting with the group coordinator.

Advisors: Advisors are chosen on the basis of their accredited senior leadership roles, as well as for their past NATO-ASI/ARW experience. The main duties are to:

(i) assure efficient and effective group discussion interaction also with other groups;

(ii) closely work with the group reporter.

Reporters: Reporters are to collect all question statements, written notes, discussion results, i.e., act as the recorder of discussions. The main duties are to:

(i) streamline discussion results and direct the writing of their contributions to the proceedings for the intermediate,final draft and print-ready group discussion reports which are limited to about five to eight pages each;

(ii) closely work with both the Advisors and the Co-Editors on the final individual group reports and the overall summary of discussion group activities;

(iii) deliver final manuscript draft to the Workshop Director & Proceedings Editor.

IX-1 FINAL REPORT OF WORKING DISCUSSION GROUP: W-A

ASSESSMENT OF LITERATURE ON POLARIMETRIC THEORY & APPLICATIONS (NATO-ARW -DIMRP'88 BOOKSHELF)

Abstract: All participants of the workshop, who published pertinent treatises, monographs, text and/or research books on "direct and inverse methods applicable to radar polarimetry," were invited to make available one desk copy for display at our **NATO-ARW-DIMRP'88 BOOKSHELF** during the entire event (see list attached). In addition, the authors were invited to share on their experiences and to identify relevant issues not covered in their texts, specifically

1. To list all relevant texts and to provide succinct one-page" assessments;
2. To identify shortcomings, apparent oversights, misrepresentations, confusion in standards, and nomenclature,etc.;
3. To recommend, as a result of their evaluation, titles and topics for new basic texts, new introductory and tutorial text books, and for advanced books including suggestions for near future ARWs.

Coordinator: G. Wanielik
Moderators: H. Mott and J.R. Huynen
Advisor: D.T. Gjessing
Reporters: **F.A. Molinet** and **Z.H. Czyż**

Working Members: (bold: highly active; *not present but input received)

R.M.A. Azzam*	H. Hellsten	I. Olin*	H. van Brunt*
W-M. Boerner	W.A. Holm	A.J. Poelman*	**J.J. van Zyl**
Z.M. Czyz	A.R. Holt	**L. Preiser**	M. Vogel
J.L. Eaves	**J.R. Huynen**	L.W. Root	E.K. Walton*
A. Farina	**G.P. Können**	A. Schroth	**G. Wanielik**
M. Feinstein	J.A. Kong*	**M. Sekine**	**D.R. Wehner***
D. Guili	**L.P. Ligthart**	D. Solimini	**S.P. Wei**
D.T. Gjessing	E.A. Mueller	K. Stiefvater	**W. Wiesbeck**

A. Literature Assessment and Recommendations

1. On the basis of the books displayed at the Bookshelf, and by referring to Western and Eastern publications, it was felt that a thorough inventory is required and that especially pertinent Russian, Chinese and Japanese treatises must be translated.
2. After some discussion, it was felt that there exists a great need for clarification of terms (key words) applicable to radar, such as: polarization state, polarization efficiency, polarization ratio, partial polarization, partial coherence, reciprocity, scattering matrices (Sinclair versus Jones, Mueller versus Stokes), coherency vector and matrix, measureability and matrix decomposition, transmit/target/receive coordinate systems, re/de-polarization, polarization-transformed, etc.
3. A list of tutorial papers clarifying these matters was felt of great urgency and that a well-prepared and updated list of key

words should be prepared and distributed among participants of this NATO-ARW-DIMRP'88.

4. It was suggested that inputs should be submitted to the Standards Committees of IEEE, IEE, DIN, ANSI, etc. so that procedures for clarifying nomenclature and standards applicable to "radar polarimetry" may be included. It was recommended that the workshop director address this issue after completion of the Proceedings.

B. List of Some of the Displays of the NATO-ARW-DIMRP'88 BOOKSHELF
(bold: by participants; * post-workshop addition)

Dedication Document:

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Miscellaneous Books, Monographs and Pertinent Reports:

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IX-2 FINAL REPORT OF WORKING DISCUSSION GROUP: W-B

CHARACTERIZATION OF SCATTERING SURFACES AND MEDIA

Abstract: The recommendations of Working Discussion Group **W-B** are in the areas of general theory and modeling, polarimetric descriptors, computer codes, measurement, data bases, and "new directions". Although many of the recommendations are best implemented through individual efforts of various principal investigators, some are also proposed as group action items for implementation through NATO during future workshops. In total, it was an extremely productive and lively working atmosphere.

It is emphasized that several of the recommendations and observations are nearly identical to those from the working discussion group activities of the NATO-ARW-IMEI in 1983. This indicates a need to maintain a focus upon these recommendations and observations throughout the next few years, as this will influence the pace of future progress in radar polarimetry. This must be done not only on an individual basis but also as a group effort. Furthermore, much ground will be lost if the issues in the NATO-ARW-DIMRP reports are not re-surfaced among the ARW participants prior to a future ARW a few years hence. To help preclude this possibility, an **informal Newsletter** is proposed for the participants of the recent ARW and to be initiated by the Workshop Director after completion of the Proceedings.

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1. General Theory and Modeling

Computational theories and tools such as physical optics should be examined for possible extension to polarimetry. Polarization dependence should be included, both for continuous media (such as aerosols and atmosphere) and for metallic and non-metallic discrete objects.

More research is needed on deducing the polarimetric characteristics of dispersive media.

Various long-standing issues require prompt resolution. These issues include the equivalence of various types of averaging (for example, ensemble versus temporal versus spatial), reciprocity-related matters, and the validity of quasi-monostatic data (insofar as this issue can be addressed through analysis), as they relate to polarimetry.

A partial overhaul of modeling approaches is necessary. Physical models (of targets, clutter, and other scattering media) and electromagnetic models should be more closely linked, so that the interaction of the electromagnetic wave with the scatterer is modeled deterministically and physically — not statistically. It is not good to continue relying exclusively on the dubious art of curve-fitting or on statistical parameters such as correlation lengths, etc. A deterministic physical model, in turn, requires that the electromagnetic interactions between the wave and scatterer be known.

At the same time, when statistically based models are still used, the statistical parameters should likewise be related to scatterer observables. This is particularly needed in the case of the covariance matrix, which has been identified as a valid scatterer descriptor. Further development of the covariance matrix as a descriptor is needed, and identification of various matrix properties with the observables will help make this possible. (To date, most covariance matrix calculations have been for simple problems such as small particle scatter, physical optics rough surface scatter, and the first and second Born approximation in volume scattering). Only then will it be more appropriate to formulate scattering problems in terms of the covariance matrix and other statistical parameters.

Furthermore, models should start with as few parameters as possible — particularly if the models are statistical. Unnecessary parameters often obscure physical phenomena and functional relationships. Models may then be improved iteratively, to include the addition of needed parameters, when the results of measurement so indicate.

2. Polarimetric Descriptors

Much work is still needed in scatterer decomposition theorems, algorithms, and outputs. First, it is necessary to validate various decomposition theorems and algorithms. Then, the uniqueness of their outputs must be determined, and their performance under noise-contamination must be assessed. Finally, the outputs of these decomposition theorems or algorithms should be identified with scatterer observables where possible. This will enable the identification of optimal descriptors in radar polarimetry.

Such efforts should not be limited to high frequencies but instead should be extended to intermediate frequencies, for which interpretation of the descriptors may be less straightforward. For intermediate frequencies, the identification and interpretation of polarimetric descriptors is a necessary effort in itself. As an example, how is the double-bounce descriptor (Huynen parameter ν) interpreted for cases in which ray-optics is no longer valid? Similarly, how does one interpret the Huynen parameters A, B_o, B, C, D, E, F, G, and H for intermediate frequencies and is their definition useful and valid at all ? Alternatively, are new sets of descriptors more appropriate for intermediate frequencies?

An appropriate follow-on effort would be the identification of the main classes of scatterers — natural versus man-made — based on polarime-

tric (with other) descriptors. This might eventually lead to the development and use of expert systems.

There also exists a need for more emphasis on time-varying scatterers and on partially-polarized waves. (Here arises the need to resolve the issue of averaging equivalences). Where applicable, the aspect-independent polarimetric features of targets and other scatterers must be identified, whether these be currently-known or new descriptors. Then, these features must be exploited so as to minimize loss of information and maintain polarization optimization of the transmit and receive antennas. As an example to consider, how should the antennas be matched to an "average" target or other scatterers (however "average" is defined), and what information is lost due to time variation of the scatterer and its reflected signal? The literature should include more examples involving both time-dependent and partial polarization.

In the case of discrete objects (targets), the identification of "configuration-independent" polarimetric descriptors — if any — would be useful. As an example, is it possible to use polarimetry in the design of a target-identification waveform, which can identify various targets irrespective of control-surface positions, wing positions, or external stores (ordinances)?

3. Computer Codes

Electromagnetic modeling computer codes should be upgraded to include polarimetric outputs (full Sinclair scattering matrix, Mueller matrices, or covariance matrix, for example), where this is needed and possible, and the polarimetric outputs should be validated. This is particularly necessary for codes which model diffraction by non-metallic objects. (The last few years have seen increased interest in the validation of electromagnetic modeling computer codes, though few of these codes are truly "polarimetric").

The capability to model anisotropic materials, dispersive materials, and similar media would be a further useful refinement to a number of existing computer codes — or possibly an impetus for new codes.

There exists an acute need for one or more "standard" codes, with these polarimetric capabilities, which can be made available to all NATO countries.

4. Measurements

Hence, all measurements of polarimetric data should specify completely the measurement system, its limitations, the measurement methodology, the quantities measured, and all conventions used (such as quantity definitions and coordinate systems). Similarly, the parameters of measurement (such as bandwidth, field tapers, and measurement time scale relative to scatterer decorrelation time) should be specified.

In the case of natural or environmental scattering scenarios, more attention ought to be paid to collecting with minute detail background and ground truth information including ambient atmospheric conditions (rela-

tive sun position, cloud cover, wind direction and speed, humidity, precipitation, etc. — versus relative target motion).

There is also a need to identify current and future requirements for polarimetric data measurement and utilization, and to find ways to meet those requirements. Some of these requirements involve instrumentation, for example, the polarimetric capabilities of sensors as well as new (polarimetry-driven) needs in radar and system stability and accuracy (in frequency, amplitude, and phase). Polarimetry will likewise drive new requirements for calibration targets and procedures, scale models (fabrication and accuracy), data sampling rates, antenna polarization optimization methods, and polarimetric system information availability. Moreover, there will arise new requirements for computer speed, memory, and algorithmic capability, particularly when real-time processing of data is involved. Likewise, there are already new requirements in the areas of data validation and contaminant identification. In polarimetric measurements, the effects of multipath, clutter, intervening media (such as the atmosphere), system noise, and extraneous background (due to measurement instrumentation) can produce errors far greater than they produce in "conventional" radar measurements such as amplitude-only HH and VV. Finally, polarimetry in combination with other special measurements (such as bistatic) will impose still other requirements. All of these requirements must be identified and met.

It is also proposed that the relatively good calibration characteristics of radiometers be exploited towards cross-calibration of radars, once relations between backscatter and emissivity are established. Such relations are also of interest for a better understanding of electromagnetic wave interactions with natural and man-made surfaces.

5. Data Bases

Maximum use of existing data bases is recommended, especially since much funding has been spent on collecting data while correspondingly little funding has been spent on "ground truth confirmation", and on analyzing, documentation, and packaging of the data. It is necessary to identify existing data bases, such as the European RCS Data Base. Data bases which are available to all NATO-ARW-DIMRP participants would be especially useful. These should include (but hopefully are not limited to) measurements of "clutter" or "ground truth" in every minute detail.

Next, the available data should be documented, validated, interpreted, put into a uniform convention and format, and properly "packaged" for further use. It is particularly important to document the calibration procedures, coordinate systems used, parameters of measurement, and the limitations of the equipment and facilities used (such as polarization isolation and sidelobe reduction, etc.). The data in these existing data bases can be used to improve the linkage between theory and experiment.

In addition, an international data base for polarimetric data should be established and maintained through the Scientific Affairs Division of NATO. The ARW-DIMRP participants and others can be kept aware of new additions to the data base (and other "polarimetry news") through a periodic Newsletter or informal Interaction Notes, which should also be

prepared and distributed directly by interested participants and not only by the Workshop Director.

It was found that most of the existing useful data bases are classified or "origin-restricted", and that we all require easier access to all available data banks pertinent to the advancement of radar polarimetry, whether classified or not!

6. New Directions

It is suggested that possibilities be assessed for the use of polarimetry in the design of exotic waveforms.

Furthermore, polarimetric descriptors might be useful in developing artificial intelligence (AI)-like methods for target recognition, independent of time and aspect (orientation). One polarimetric descriptor (Huynen parameter ψ) already enables the removal of effects due to target rotation about the radar line-of-sight. The removal of effects due to other variations in target orientation is more difficult; nonetheless, for optical frequencies, the human brain and eyes have the capability to recognize objects from different aspects. In developing a similar capability for radar, polarimetry may prove useful. The failure to examine this possibility would be a grave mistake. Group-theoretic polarimetric target classification algorithm development should be advanced strongly.

7. Group Activity Items

A group effort, with NATO support, is needed to support the following endeavors:

1. polarimetric computer code development and standardization;

2. identification of existing polarimetric data bases and establishment of new ones, together with documentation and standardization;

3. establishment of standards for measured and predicted polarimetric data (notation, displays or outputs, formats, coordinate systems);

4. standardization of polarimetric data measurement procedures (such as calibration).

Standardization is intended only as a convenience for users of polarimetric data and should never preclude new approaches to prediction or measurement; i.e., the rapid advancement of radar polarimetry must not be hampered or curtailed by rigid conventions.

8. Informal Newsletter, Interaction Notes and Recommendations

An informal Newsletter or Interaction Notes are proposed to facilitate the exchange of polarimetry-related ideas and information between ARWs, particularly across national and disciplinary boundaries. Such a Newsletter should be initiated by the Workshop Director and a small board of international correspondents after completion of the Proceedings of this Workshop, with the intention to:

1. promote the implementation of various recommendations as stated in the working discussion group reports;
2. provide continuing mutual guidance for polarimetry research and application, and especially identify controversial unresolved problems;
3. promote interaction between theorists, sensor system designers, and the end users of polarimetric data;
4. announce new polarimetry-related papers, monographs, etc., as they are published in various journals;
5. help minimize unwanted duplication of effort and identify incorrect approaches.

Finally, we recommend that NATO consider funding research in radar polarimetry, particularly research which addresses the needs identified in this working discussion group report.

CONCLUSIONS

As an overall concluding observation, it was suggested that more emphasis be placed on assessing recent advancements made in "polarimetric bionics" and that we may be able to derive a great amount of information and "still undiscovered basic principles" by pursuing such assessment studies. It was suggested that during a third NATO-ARW on the subject matter one or more sessions be dedicated toward the introduction and assessment of new discoveries in "polarimetric bionics", and that some expert tutorial overviews on the subject matter be given.

Furthermore, an all-together separate NATO-ARW on the subject matter of "Polarimetric Bionics" in conjunction with our series of three NATO-ARWs may be desirable. It was suggested that Prof. Pierre C. Sabatier convenes a special session during one of the forthcoming RCP-264 at USTL, Montpellier, France and have this subject matter properly "aired" and the connections to "electromagnetic inverse problems" established.

As was pointed out repeatedly by Dr. Günther P. Können during his active discussion group participation, polarization is as important a property as colour in light [0-2]. It was suggested that more attention be paid to advances made in analytic and metrologic studies dealing with the unravelling of so many, yet, unexplained polarimetric effects on atmospheric optics because these polarimetric effects are -- to a great extent -- created by rough surface and volumetric scattering as well as internal hydrometeoric crystal lattice diffraction. Either a special session or the convening of another separate NATO-ARW on the subject matter of Polarimetric Atmospheric Optics was highly recommended.

This Working Discussion Group also concluded that its overall recommendations should be made known and summarized during the forthcoming PIERS (Progress In Electromagnetic Research Symposium) events organized so diligently by Prof. Jin-Au Kong of the Electromagnetics Theory & Applications Laboratory, MIT, Boston, MA/USA, and during other similar events related to this specific topic.

IX-3 FINAL REPORTING OF WORKING DISCUSSION GROUP: W-C

INVERSE SCATTERING WITH SPECIAL ATTENTION TOWARDS IMAGING

Abstract: Working Discussion Group **W-C** was engaged in heated discussions. Instead of assessing the overall state-of-the-art, isolated problems were chosen and the reader is encouraged to address the pertinent Reports of the Working Discussion Group Activities of the first NATO-ARW on the subject matter of "Inverse Methods in Electromagnetic Imaging" very carefully! This Working Discussion Group **W-C** chose to discuss (i) linear inverse scattering, (ii) non-linear inverse scattering, (iii) a priori information inclusion, and (iv) specification of terminology: discrimination versus classification versus imaging versus identification. The main objective was to establish a firm base assessment for the rapid development of vector (polarization) diffraction tomography.

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1. Linear Inverse Scattering

1.1 There exists a "unified theory" for diffraction tomography within the ranges of the Born or the Physical Optics - approximation: [PO];

1.2 The spatial resolution is limited by diffraction;

1.3 The consequences of limited data (e.g. limited aperture or bandwidth) can be predicted.

1.4 The object function of an imaging system could be, for example:

1.4.1 $\varepsilon(x,y,z;f)$ for continuous dielectrics
(Born approximation for linearization)

or

1.4.2 $z(x,y)$ for metal surfaces
(PO - approximation for linearization);

1.5 The numbers of dimensions in data collection should be equal to or greater than the number of dimensions in the object function (Devaney's "Golden Rule"):

1.5.1 In general, three-dimensional dielectric case: data (α_t, ζ_t; α_r, ζ_r; f) is five dimensional; object $\varepsilon(x, y, z; f)$ is four dimensional (over determination);

1.5.2 Example: single frequency single view holography: only two dimensional objects can be reconstructed uniquely;

1.5.3 In monostatic imaging, frequency diversity techniques have to be used to collect spatial information;

1.6 For a known dispersion of {Re $\varepsilon(f)$} one could synthesize pulses from equidistant samples not in temporal frequency f; but in $|\vec{K}|$.

1.7 Stochastic scatterers can cause unwanted speckle (spatial noise) in the image. To suppress this, one could use:

1.7.1 incoherent addition of several independent (e.g. in view angle, f) images. → (loss of resolution);

1.7.2 use of large relative bandwidth (this was controversial!). The analogy between "speckle" and "undersampling" was also controversially discussed.

1.8 Sometimes only reflection mode data can be collected (e.g. subsurface targets):

1.8.1 Then only half of the Fourier space is available, consequently Re(ε) and Im(ε) cannot be determined independently;

1.8.2 Lack of low frequency coverage could cause problems in image interpretation.

1.9 We might learn from nature to define "wave-shapes" to fill the bandwidth needed (e.g. "T-Pulse");

1.10 Error-insensitive algorithms should be found, using overdetermination. They should be robust against:

1.10.1 measurement errors,

1.10.2 phase distortions by errors in the assumptions on the propagation medium (e.g. inhomogenuities).

2. Non-Linear Inverse Scattering

2.1 Non-linear inverse scattering means inclusion of multiple scattering leading to solutions more precise than the Born approximation.

2.2 The one-dimensional problem (layered structure) has been solved using reflections of a causal pulse.

2.3 The problem is not solved for general two-dimensional or three-dimensional objects!

2.4 This corresponds to the Newton-Marchenko equations which have not been solved.

2.5 There are doubts that there exists a unique solution at all; and we do not know if there is hope towards finding it, especially as regards the general three-dimensional case.

2.6 Optimization methods might be tried to come to an object reconstruction. One could perhaps provide a "crude force" random optimization with some "intelligence" using the inverse theory of a priori knowledge:

2.6.1 For some of these methods cost may grow less than exponential with the size of the object. (Analogy to "freezing a physical body from highest temperatures"). This has been vividly discussed and the total issue was considered to be highly controversial.

2.7 Thinking in time-domain might help to invent inverse algorithms, even though data in time and frequency domain are equivalent. Yet, with the advent of "Ultra-Wideband Polarimetric Impulsive Sensor Systems," the time domain approach may have to be assessed at once and with full vigor!

2.8 We are not sure if vector diffraction approaches using polarimetric data can, today, bring us much closer to a solution of the nonlinear inverse problem in general. Even though odd/even multiple reflections can be distinguished for metal-surface-objects, the advantages for the continuous dielectric media are not clear. However, it was found that a complete "tensorial" treatment of vector diffraction tomography eventually will have to be developed for inhomogeneous layered and heterogeneous media with purely dielectric, lossy dielectric, or conducting artifacts of subtle changes in constitutive parameters (ε, μ, σ).

3. A Priori Information

3.1 This could be, e.g. the type of the object function (metallic, lossless, dielectric, etc.).

3.2 If there is only a limited number of discrete scatterers of known structure (e.g. point scatterer), their precise positions can be calculated if the data have good enough s/n ratio:

3.2.1 This is one aspect of "super-resolution": one can effectively extend the aperture or bandwidth using such information.

3.3 The object may only have a limited spatial or spectral extent.

3.4 Symmetry properties may be exploited, especially with polarization measurements.

3.5 Then questions remain in general:

3.5.1 How does one include a priori knowledge in the algorithm?

3.5.2 How does one interpret the image with the knowledge about the object?

4. Additional Remarks

4.1 "Imaging" versus "Classification of objects" are very different tasks, and some tutorial papers on the subject matter are in need.

4.2 Development in sensor technology towards a fast area microwave sensor would be valuable.

4.3 "Benchmark tests" could test different inverse algorithms on standard object data.

4.4 In medical applications, tissue characteristics obtained in vitro may be different from those in vivo.

Symbols used in Working Discussion Group W-3:

ε = permittivity

x,y,z = Spatial coordinates

f = Frequency

α_t, ζ_t; α_r, ζ_r = Angular direction of view from transmitting/receiving antenna

$\vec{K}$ = Wave vector

PO = Physical Optics

CONCLUSIONS

The reader is strongly encouraged to obtain a copy of the Proceedings of the first ARW and to assess carefully the recommendations made in the pertinent Discussion Group Reports which are dealing with some of these issues in much greater detail.

Prof. Karl J. Langenberg referred to the truly excellent research text book on "Tomography and Inverse Problems" recently published with the Malvern Physics Series, Adam Hilger, Bristol, 1987, edited by Prof. Pierre C. Sabatier (see booklist of IX-1: [70]).

It was also suggested that close coordination of these sets of NATO-ARWs with the RCP-264 Workshop on Inverse Problems, organized by Professor Pierre C. Sabatier at USTL, Montpellier, France annually during late November/early December, be maintained. Especially, it was suggested that the subject matter of "Polarimetric Bionics" be covered both at RCP-264 and during the third NATO-ARW scheduled for 1993.

IX-4 FINAL REPORTING OF WORKING DISCUSSION GROUP: W-D

PROCESSING, FORMATTING AND CALIBRATION OF POL-RAD/SCAT AND POL-SAR/ISAR MEASUREMENTS

Abstract: Working Discussion Group **W-D** was a very active and productive team effort. After extensive deliberations, twelve (12) major issues were broadly consolidated into two (2) main categories, namely:

1. Polarimetric Processing
   - i) multidimensionality of data estimation of these data
   - ii) assumptions made in preprocessing
   - iii) simultaneous Doppler and polarimetric processing
   - iv) data format
   - v) detection

2. Polarimetric Systems Calibration
   - i) phase reference
   - ii) antenna
   - iii) calibration targets
   - iv) requirements
   - v) pre/in/post-flight calibration

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A. POLARIMETRIC PROCESSING

1. Polarization Vector Processing

1.i **Multidimensionality:**
Polarization → long history because of essential nature of EM field history wound around efforts to use it in distinguishing military targets from surrounding background;

Two dominant factors:

versatile (polarization ratio) radius - cross polarization isolation;

concerns:
- optimal data reduction - feature extraction,
- display of data,

- estimation of data - sensitivity to noise,
- development of proper descriptive target models,
- theory is needed desperately;

1.ii **Assumptions in processing:**
- assumption of aspect invariance in preprocessing,
- averaging of amplitude and phase,
- speed and memory of CPU-important considerations,
- correct representation,
- description of processing procedures should be given to the user;

1.iii **Simultaneous Doppler and polarimetric processing:**
- simultaneous or separable,
- system specific (e.g., weather radars: done simultaneously);

1.iv **Data format:**
- input for new algorithms,
- calibration,
- NATO data format,
- high resolution complex data preserved,
- 2x2 Sinclair scattering or 4x4 Stokes reflection matrices,
- data volume is an issue;

1.v **Detection:**
- new advances are needed in the field of optimum and sub-optimum receivers for target detection with polarimetric radars,
- modeling is important,
- new theory is needed;

2. Polarimetric Calibration

2.i **Phase reference:**
- could be amplitude dependent;

2.ii **Antenna calibration:**
- requirements are application specific,
- standardization of terminology,
- antenna calibrated in configuration of user,
- components - full systems - system dependent.

3. Polarization Information Processing

Polarization has a long history of use in radars, possibly from the birth of radar, because of the essential vector nature of electromagnetic waves as discovered commencing with the historic experiments of Heinrich Hertz in 1888. Its history, commencing with the detection and ranging experiments by Hülsmeyer of 1896-1904, is wound around the efforts to use it in distinguishing military targets from their surroundings. These dominant factors seem to be fueling the resurgent interest in this area.

3.1 Advent of versatile polarization hardware technology (good cross polarization isolation) with this precise phase and cross polari-

zation information of the scattering matrices being available.

3.2 There is a refocusing of interests in the theory in finding correct, if not unique, representations of polarization information. The aim is to uniquely describe information inherently characteristic of different types of targets. This is what was considered as the spirit leading to the formulation of the violently debated decomposition theorems of Huynen and Cloude. This is also very much in the spirit of the continuing attempt to develop robust target identification algorithms.

3.3 A fairly new development is the advent of high resolution polarization diverse imaging radars. The principal driver in this technology is the extraction of useful information for use in remote sensing applications. Data representation encompassing all the polarization and frequency dependent information is desired, i.e., translation of information into the image, where each pixel is characterized.

3.4 The committee recognized the need for better information display including new methods of feature extraction, interpolation, and optimal data reduction of isolated and distributed scenarios. Too much is left for human interpretation especially in SAR data processing, and a very new concentrated effort on feature extraction mated with simultaneous data reduction is badly needed.

3.5 The applicability and usefulness of various "wavelet presentations", originally developed in quantum mechanics, to the optimal display of polarimetric target and clutter characteristics representations was considered timely. Especially, the concept of "polarimetric wavelets" to the interpretation of wideband multispectral but also ultrawideband impulse radar scattering results should be further advanced.

4. Broadband Polarimetric Radar Signals

The application of polarimetric techniques in high resolution radars is highly promising. In this field of applications, the use of broadband signals is needed, for example, as means for increasing range resolution. In this case, polarimetric techniques can provide more distinctive polarimetric features of radar objects, thus increasing radar discrimination performance.

The use of broadband polarimetric signals may require new analytic tools to model radar signals as well as the interaction between the radiated vector waveform and the radar object. The quasi-monochromatic assumption for modeling EM waves may not hold anymore. Furthermore, the radiated waveform can be modified as a consequence of the backscattering phenomenon, and the observed properties depend also on the antenna polarization. Based also on these considerations, the development of proper signal and target models appears needed for advances in the field of applications of high resolution polarimetric radars.

5. Assumptions in Pre- and Post- Processing

Various assumptions are made in the processing of radar data. These assumptions include the analog and digital specifications of the radar

itself and signal processing done with the radar both in hardware and software. The driving forces behind many assumptions made in hardware and software are speed and memory considerations. Of special concern is the effect of "pre-summing" or "averaging" of data (over adjacent "bins" or "pixels"). Careful consideration must be given to the effect of this type of averaging on both the amplitude and phase of polarimetric data. In a polarimetric system the different polarization signals are often pulsed and are not recorded simultaneously. In a moving system this can cause an offset in the image between channels. In a SAR system the data is processed assuming targets in the image are aspect-invariant and time-invariant over the processing aperture. Because of the many methods, definitions and assumptions made in processing radar data as well as in the hardware itself it is recommended that providers of data supply concise descriptions of any and all definitions and assumptions they made. These descriptions should include details of any post-processing calibration and corrections or standard processing of data, as well as on the lack or incompleteness of ground truth acquisition, as a "complete ground truth collection procedure" has yet to be developed and just does not exist !

6. Simultaneous Polarimetric & Doppler Measurements

There is a need in the meteorological community to perform simultaneous measurements of the polarization variables at the same time as the estimation of the three most conventional variables in use in radar meteorology: (i) reflectivity (time range and co-polar return), (ii) the mean Doppler velocity (first moment of velocity spectra), and (iii) the width of the Doppler spectra (second moment of velocity spectra) are collected and processed. There are several conflicting requirements that must be met or at least arbitrated if all of these measurements are to be made simultaneously. If linear polarization is considered, for example, one must wait a reasonable time between transmissions of the vertical and horizontal pulses or in most cases the echoes further from the transmitter will obscure the subsequent pulse measurements (particularly the cross polarization component). The long pulse repetition time on the other hand causes the phase references for the next pulse to be difficult to assess due to Doppler shifts. In addition, the estimation of the mean Doppler shift requires some modification (Zrnic, **[VIII-7]**) or the estimation can become meaningless. In many applications the separation of Doppler processing and the polarimetric processing is desirable. Thus, there may be advantages in separating these to be able to provide better separating estimates and possibly provide more dimensions to be considered in the analysis.

The group generally agrees that the whole subject of simultaneous polarimetric and Doppler measurements is very strongly influenced by the applications, but that, in general, a unified analytic approach must yet rapidly be developed irrespective of any applications.

7. Polarimetric Data Format

For high resolution single scatterer measurements, the 2x2 complex Sinclair scattering matrix is the natural choice for the data format. For polarimetric SAR systems, however, the data volume involved becomes staggering. For example, the JPL CV-990 polarimetric SAR images con-

sisted of 4096 pixels by 1024 lines. To store one image in the complex scattering matrix format, 128 Mbytes per image would be needed. However, this type of data must be available if single targets are to be studied, or if maximum discrimination of low RCS targets in a dynamic background clutter is to be achieved.

In the case of geophysical radar remote sensing, spatial averages of the radar backscatter are usually calculated, since this quantity is predicted by analytical models. Then, the Stokes matrix format is the natural choice for presenting this type of very coarse data because spatial averaging performed on the Stokes matrix is quasi identical to spatial averaging of the radar backscatter cross section while at the same time processing the polarization information contained in the data. In addition, this incoherent averaging process reduces the effects of speckle considerably (but not optimally), which is intrinsic to SAR systems. JPL has implemented a data compression algorithm (von Zyl, et al.; Dubois, et. al.) employing spatial averaging and special ways of formatting the Stokes matrix data [VII-1 and VII-2], resulting in storing an image in only 10 Mbytes of memory as compared to 128Mb. Operating on the Stokes matrix data also reduces the time needed to synthesize an image (for a given transmit and receive antenna polarization combination) by a factor of 10 (from 20 minutes to 2 minutes). However, we emphasize that whereas for geophysical data interpretation this "ruthless averaging approach" may be tolerated, this is not so at all in target detection and low RCS discrimination and in super-high resolution imaging!

Similar concerns exist in the polarimetric weather radar community. Since the experience of the scientific community with polarimetric SAR data is still so limited, we conclude that, while data reduction should be strongly encouraged and investigated, the original high resolution complex data should be preserved for use in those cases when spatial averaging is undesirable. Also, it was not only considered most desirable, but of urgent need to select families of "training data sets" amenable for comparison of algorithm development by different modelers.

8. Detection

New advances are desirable in the field of optimum and suboptimum receivers for target detection with polarimetric radars. This requires proper statistical modeling of targets and interference as well as the application of statistical decision theory methods to vector signals. The receiver structure should put in existence the relationship with polarization features of signals in order to exploit the acquired knowledge on phenomenological and physical properties of the backscattering with different types of radar objects. Receiver adaptivity in accordance with the polarization behavior of radar signals can play an important role. The development and evaluation of multi-channel/multi-dimensional signal processing methods for target detection is also desirable for the application in polarimetric high resolution radar. This is also important for comparison between optimum and suboptimum solutions.

B. POLARIMETRIC SYSTEMS CALIBRATION

9. Antenna Calibration Concerns and Preliminary Comments

It is generally agreed that one of the critical problems of any

instrumental equipment is the need for careful calibration, and this is particularly true for polarimetric radar systems. The procedure for accomplishing this calibration test is not standard because of the wide differences in the types of radars as well as the types of applications for which the radar is designed.

There are three general methods in use for calibrating dual polarization antenna systems. One is to utilize an antenna range using either near or far field measurements to determine the gain as a function of viewing angle for both co- and cross-polarized components. In most cases, reciprocity is involved due to the use of non-linear non-reciprocal ferrite polarization switches. The answer to the question as to the suitability of either the near or far field approaches is, apparently, one of convenience. The near field technique is easier to implement for larger antennas at low frequencies because of physical limitations. A second technique is a more systems oriented approach where various known targets or active radar calibrators are placed at strategic locations and viewed by the radar antenna. These techniques would seem to provide good calibration results, but with the difficulty of ensuring a location without interfering signals from the surrounding clutter or other unknown radiation sources. A third procedure is to look at signals from extraterrestrial sources. In any case, it was noted that antenna patterns should be measured after installation including all "polarization channels(AA, AB, BA, BB)" on isolation, sidelobe reduction, reciprocity, ground clutter suppression, etc. It was pointed out that an antenna range pattern may provide a good starting point which may have to be adjusted by usage with standard active and passive targets. Calibration may be extended by using some of the established ground-clutter characteristics natural to the range in use.

10. Choice of Passive and Active Calibration Targets

The external calibration of polarimetric radar systems is a difficult task because the many polarization states that can be operated by such systems do not match the capabilities of single passive calibration targets known to date. Especially, the calibration of cross polarization is still problematic.

Active calibrator systems are more flexible in this respect. In addition to the possibility to select the polarization state, the cross section can be easily adjusted.

Depending on the application, a frequency shift or a time delay may be applied in the active calibrator in order to increase the signal to background ratio and to improve the accuracy of the calibration. These active polarimetric calibration approaches were pioneered at MICOM, Redstone Arsenal, and here we refer to the paper by its inventor, Lloyd W. Root [III-7]. More recently, active calibrator-based calibration methodology was strongly advanced by the CAL-TECH/JPL and the DLR POL-SAR calibration teams, and we alert the reader to a planned series of forthcoming calibration workshops on the subject matter.

11. General Calibration Definitions

It was found essential that two technical committees be convened to de-

rive a set of consistent polarimetric definitions: one for POL-RAD and POL-SCAT and one for POL-SAR and POL-ISAR systems. Calibration procedures and specifications must be sub-system oriented and not necessarily to the end product. Specifically, a systematic approach is in need and the precise meaning of calibration versus precision and accuracy must first be given. In addition, there exist related terms such as absolute versus relative calibration, internal versus external calibration, pre/in-flight/post-operational systems calibration, etc.

It was found that specific nomenclatures may differ for calibration of polarimetric radar and scatterometer systems versus POL-SAR and POL-ISAR systems as, for example, "bin versus pixel", down/cross/double-cross-range, resolution versus correlation cells, etc. Also, the precise identification on the completeness of a "polarimetric sensor/imaging system" with respect to the measurement of absolute and relative polarimetric channel amplitudes and phases requires precise definitions and new calibration procedures. These multiple-polarization channel calibration parameters are still not defined properly and it was found that a series of special workshops addressing the questions are in need.

12. Ground-Truth Specification and In-Situ Calibration of Complementing Ground Observing Systems

Although we have witnessed decisive advances in the procedures for planning campaigns, any polarimetric systems calibration — as perfect as it may be — is futile unless also precise information on the calibration of separate complementing background and ground-truth observing systems (video, optical, IR, radiometric, dosimetric, biologic, chemical, physical contact, etc.) are simultaneously given. It will be essential to develop highly improved methods of correlating POL-systems with multidirectional (geometric, atmospheric, geophysical) observing systems calibration approaches. The procedures currently initiated within various NATO radar establishments are still highly insufficient and so are those of the NASA/ESA/ISAS SAR operating establishments. Coordinated international workshps including Eastern Block calibration experts are desperately in need.

CONCLUSIONS

It was unanimously agreed that the entire topic of processing, formatting, and calibration of POL-RAD/SCAT/SAR/ISAR measurements is one which requires a lot of attention, and the immediate appointment of NATO-RSG and NASA/ESA/ISAS workshops on the relevant metrology and calibration were considered vital for advancing the field. Especially, it was suggested that NATO-SAD address this problem carefully and that the Workshop Director place more emphasis on these topics during the forthcoming third NATO-ARW in 1993. Furthermore, it was strongly recommended that the results of these identified activities of **W-D**, must provide definite input for **W-E** on the "Unification of Nomenclature Conventions and Standards in POL-RAD/SCAT and POL-SAR/ISAR Sensing and Imaging".

IX-5 FINAL REPORTING OF WORKING DISCUSSION GROUP: W-E

UNIFICATION OF NOMENCLATURE, CONVENTIONS AND STANDARDS IN POL-RAD/SCAT AND POL-SAR/ISAR SENSING AND IMAGING

Abstract: Working Discussion Group **W-E** was given the question of assessing the current state of pertinent nomenclature, conventions, and standards. The question was approached in general and with respect to the proceedings of the conference. Although the members of the group, who interdigitized most vividly with the other four basic groups **W-A** to **W-D** and also with **W-F**, agreed on the need for standards, no agreement was reached on the details for various reasons.

Several views on standards were given. One view was that some existing standards should be agreed on. Standards mentioned were the standards in optical and radio astronomy, the IEEE and IEE Standards, the DIN standards and a putative working standard derived from basic texts and papers in the field. In a second view, some uneasiness was expressed about setting fixed standards in a field in which the workers are still looking for the basic significant variables, and a more "dynamic open-ended" modeling approach towards identifying the pertinent issues for a "framework for future standards modeling", was suggested.

The group decided eventually to make a statement on requirements for clarity and definitions in written contributions to the conference, and if possible, to provide a list of recommended symbols and definitions. Input to this group **W-E** effort acrued from requests by all of the other groups **W-A**, **W-B**, **W-C**, and **W-D** in particular.

The contributions received from members of **W-E** were a list of general recommendations for authors. Another contribution was discussed on the problem of RHC and LHC using the descriptors: "time-frozen" and "space-frozen," used in the physics versus engineering literature.

It was generally felt that the job was a big one, bigger than could be accomplished in a short period of time, and that a separate international workshop series on developing a "framework for the establishment of useful standards as a dynamic modeling approach," should address the issue within five to ten years and should be convened by NATO-SAD. It was also suggested that during the forthcoming third NATO-ARW, this specific working discussion group effort on the unification of nomenclature, conventions and standards in POL-RAD/SCAT and POL-SAR/ISAR Sensing and Imaging be given one "full days" time allotment toward the very end of the workshop so that inputs of other working discussion group recommendations can be properly assessed and integrated into a unified final recommendation to NATO-SAD and to the pertinent national and international standards committees.

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Moderators: A.W. Root and S.R. Cloude
Advisors: M. Feinstein and V.N. Bringi
Reporters: **A. Britton** and G. **Wanielik**

Working Members: (bold: highly active; *not present but input received)

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W-M. Boerner	A. Farina	G.P. Können	A. Schroth
H. Brand	W.K. Flood	**L.P. Ligthart**	T. Suzuki
V.N. Bringi	**D. Giuli**	F.A. Molinet	H. van Brunt*
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1. On the Definition of Right and Left Elliptical Polarization

The physicist tends to view polarization spatially with time stopped. This time-invariant view has produced a right and left-handed definition based upon the spatial definition of a right or left-handed screw. The physicist merely views the time-invariant spatial picture and regardless of the propagation direction identifies the right or left handedness of the motionless wave.

On the other hand, engineers tend to view polarization from a single position in space or spatially invariant. Then as time proceeds, the engineer views the wave as it passes through a plane. Since this view is spatially invariant, the direction of propagation is required through the plane and then elliptic or circular motion with the plane as the "$\vec{E}$" vector, traces out its pattern on the plane defining the right or left-handedness of the wave. Viewing this plane along the direction of propagation makes clockwise motion a right elliptic or right circular polarization.

The questions now arise on: Who defined the screw direction as it goes into the (screwed) motion using a right-handed twist or left-handed twist? And who decides that a clock would rotate clockwise? Or, should we introduce the plus or minus helices of quantum mechanics?

2. On the proper Definition of Nomenclatures

It was felt that someone soon ought to clarify the often contradicting, opposing and all too loose usages of symbols, time-space assumptions, etc. Among a long list, the following items were chosen for consideration:

- List of Symbols;
- Explicitly define all coordinate systems;
- Define time-space dependence, e.g., exp{-i(wt-kr)} or exp{+j(wt-kr)} for a wave traveling in foward direction with increasing time; i.e., distinguish between the "Physics Standards" and the "Engineering Standards";
- Definitions of field vector components in the plane of polarization, e.g., are the polarization states defined in terms of the electric or magnetic field vectors ($\bar{E}$ or $\bar{H}$)?
- Definition of "Sense of Polarization" and interpretations on:
  - corkscrew of senses (note that nomenclature varies widely),

  - phase difference between components of field vectors (including sign),
  - ellipticity angle and its sign,
  - relation to definitions on the Poincaré polarization sphere;
- Definition of Stokes vector components in terms of field components and/or position angles on the Poincaré sphere;
- Definition of all appropriate symbols including polarization tran-formation ratios;
- Definition of Poincaré sphere projections(Polar, Lambertian, Mollweid, Aitoff-Hammer, etc.);
- Definition of Signal/Noise for vector polarization signals;
- Definition of Mueller versus Stokes Reflection matrices and its proper relations to the Sinclair matrix for degenerate coherent case;
- Definition of discriminants, contrast and image quality in POL-RAD/SCAT/SAR/ISAR imaging;
- Definition of time averaging versus ensemble averaging.

3. Appointment of International Joint Commission (IJC) on Standards in Radar Polarimetry

Because of the widely differing uses of symbols, nomenclatures and also standards - alone within NATO member countries, e.g., IEEE, ANSI, IEE, DIN, EC, etc., – it was found timely to assemble an "IJC on Standards in Radar Polarimetry", to be appointed by NATO-SAD in the not too distant future.

Attention was drawn to the fact that, with the rapid advancement of multistatic ultra-wideband polarimetric impulsive radar theory, metrology and technology, indeed the topic of developing proper standards, nomenclatures and symbols becomes crucial.

The need for such action is dictated by the fact that we require now already fundamental research text books and soon to come basic introductory level text books on the subject matter. Indeed, members of all of the six basic topical working discussion groups were seriously concerned about this unsatisfactory situation.

CONCLUSIONS

There unfortunately was just not sufficient time, nor has the field matured to the desired state of perfection that this working discussion group was able to produce a complete response toward the inputs of the other groups, received only a day before the Final Reporting Session. Thus, it is recommended that these very pertinent items on the streamlining of nomenclatures, conventions and standards be given top priority during the forthcoming third NATO-ARW on the subject matter. But, in order to come up with a uniform nomenclature, strong interaction with polarimetrists from optics is required who are struggling with similar issues (see: T. Gehrels, Planets, Stars and Nebulae, studied with photopolarimetry, Tucson, AZ: University of Arizona Press, 1974).

IX-6 FINAL REPORTING OF WORKING DISCUSSION GROUP: W-F

ACCELERATION OF INTERNATIONAL/NATO INTERACTION: DESIGN OF INTERNATIONAL NATO POL-RAD/SAR/ISAR MEASUREMENT CAMPAIGNS (ADMINISTRATIVE)

Abstract: The present ARW-DIMRP, in continuation of ARW-IMEI'83, has successfully brought together key experts and observers from a majority of NATO-member countries allowing them to judge the level of interaction and of the progress made since the ARW-IMEI'83. We refer here to the Final Report of Working Discussion Group W-F (VI.6) in the second part of its proceedings (pp. 1289-1296). Its conclusions still apply on why the enhancement of interaction is desirable and also why the mechanisms for achieving these goals have not changed substantially.

Thus, in this 1988 report of W-F, main emphasis is placed primarily on the design of international POL-RAD/SAR measurement campaigns and data exchanges, whereas most of the other relevant issues were broached in the previous report.

However, also the expansion of the charter of the NATO-SAD on planning and staging future NATO-ARWs and NATO-ASIs was discussed and considered highly pertinent for future events, especially in view of a reapproachment of the Eastern and Western Blocks then initiating.

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A. Design of International POL-RAD/SAR Measurement Campaigns

1. The military arms of NATO, through their research study groups (RSG-XX), plan and carry out campaigns with strong military inputs. These are multi-national campaigns frequently involving military targets with resulting security and classification problems. We did not consider that these campaigns were the kind envisaged by our group title, and because of their classified nature, they were not discussed here at all although some of the less sensitive results may be pertinent.

2. We are currently unaware of requests from the scientific community for an international, non-military campaign to be partly supported by NATO funding, although there exist several inter-NATO member country campaigns of definite relevance sponsored via URSI Commissions A/F/G/H, and UNESCO. Thus, if there are such plans of coordinating these campaigns with NATO-sponsored activities, they should be presented to the Assistant Secretary of NATO Scientific

Affairs, requesting the availability of travel funding.

3. International programs involving NATO countries continue to proceed without interference from the NATO organization just to mention a few:

TNO-CRREL/ARO/UMASS:	SNOW IN NEW HAMPSHIRE	FEB 1986
UNIV. MICH - TNO:	BISMARK CROSS SECTION TERRAIN TYPES AT 35 & 90 GHz	MAR 1987
DLR-COLORADO STATE:	CONVECTIVE STORMS IN GERMANY	SPRING 1988
UNI. FIRENZE - PENN STATE:	Z_{DR} AND HYDROLOGY IN ARNO VALLEY	1989-90

4. We are currently unaware of requests for international measurement campaign funds. If such plans are on the horizon, they need to be brought forth promptly.

5. The scientific community still discusses and should be strongly encouraged to address the

   (a) Assistant Secretary of the NATO Scientific Affairs and to report on this workshop activity - encouraging this meeting to take place every three years or so. Identify a committee, chaired by Dr. W-M. Boerner or his designate rather than rotating responsibility through member nations for sponsoring.

6. In addition, work to see that CHILL, CP-2, Chilbolton, DLR, and maybe also that Firenze support scientists for scientific investigations. The funds for these scientific experiments must come from outside NATO and should come from national agencies of each investigator's country. But NATO should be encouraged to provide travel funds to initiate such programs, and to assist strongly in the support of coordinating procedures.

   Especially, the use and further development of the following polarimetric instrumentation radar facilities is encouraged in addition to University-operated systems not listed here:

METEOROLOGIC	OCEANOGRAPHIC	TERRAIN	SAR
CHILL	TNO	ONERA	JPL
CP-2/NCAR	NOSC	DLR	ERIM/NADC
OTTAWA	SCRIPPS	TNO	TNO
CHILLBOLTON	NTNF	MICOM	ISAS
FIRENZE	NRL	RSRE	DLR
TSUKUBA	AFGL	CRL/Japan	ONT
DLR	DLR	NRC/Canada	DARPA
NSSL	RSRE	NOAA/ERL/WPL	DK-SAR

   However, because of decreasing budgets, the question of maintaining, operating and expanding such facilities needs to be addressed from a trans-national viewpoint. Also, with the thawing of the Cold War, close collaboration with East-block countries may soon become feasible and should be considered as viable options; particularly with Dr. Arkadij B. Shupiatskij of the USSR Central Aerological Observatory at Dolgoprudny/Moscow Region and with Dr. Aleksander V. Ryzhkov of the USSR, Academy of Sciences, Main Geophysical Observatory in Leningrad.

7. The scientific community needs to make the NATO Scientific Affairs Director, Dr. Craig Sinclair (retired as of 1989) and his replacement, Dr. Giovanni Venturi, aware of the value of this NATO-ARW-DIMRP'88 and of some of the travel grants awarded in context with this workshop activity and why the number of such grants should be increased in order to advance scientific cooperation between scientists from NATO countries in radar polarimetry.

B. Expansion of the Role of NATO-SAD in View of Dramatic Political Changes and the East-West Reapproachment

The bold attempt by the Workshop director for requesting from NATO-SAD permission for participation by expert polarimetrists from Eastern Block Poland, Czechoslovakia and Hungary and from the Asia NW Pacific Rim Japan, Korea and the People's Republic of China was well received by all participants of NATO member countries. In fact, the loud and clear request was made by many participants, by the hosts of the scientific cultural exhibitions, and by government R&D funding organizations to have NATO-SAD consider the expansion of its charter with respect to full support for non-NATO member country experts of highest international renown.

Therefore, this working discussion group W-E endorses the motion and requests that the Workshop Director, after completion of the Proceedings, approach the NATO Scientific Affairs Division in this matter:

1) Re-write and expand the charter for NATO-ARWs and NATO-ASI support to include famed experts from non-aligned NATO countries;
2) In view of the reapproachment of Eastern and Western blocks, encourage the planning and execution of joint NATO-EURASIA-AUSTRAL-Pacific Workshop, Retreats and Study Institutes;
3) Encourage the planning and execution of NATO-ARWs and NATO-ASIs dealing with pertinent topics of "global environmental planetary defense".

CONCLUSIONS

Radar polarimetry has become a mature engineering science in electromagnetic sensing and imaging of the terrestrial and planetary atmospheres and crusts, and especially for detecting and imaging hostile objects embedded in such background clutter. Because of the very high potential of implementing POL-RAD/SCAT and POL-SAR/ISAR systems for wide area surveillance in applications of global environmental planetary defense, it was suggested that during the third NATO-ARW on "Ultra-wideband Polarimetric Doppler Radar Sensing and Imaging" the pertinent division directors of national (NSF, BMFT, Mombu-sho, DFG, NSERC UK/Canada/NRC, etc.) and international agencies (NATO, UNESCO, etc.) be invited for not only assessing the progress made but more so on redirecting the focus for future multi-national, multi-institutional measurement campaigns towards fullfilling these goals. The Workshop Director and his assigned designates should approach the pertinent administrators immediately upon completion of the Proceedings and during the early planning process for the forthcoming third NATO-ARW.

IX-7 CONCLUDING REMARKS ON NATO-ARW-DIMRP'88

**Tapan K. Sarkar/Sujeet K. Chaudhuri/Yahia M.M. Antar/
Edward Moshang/J. Petro V. Poiares-Baptista**

Abstract: These concluding remarks were put together on request of the workshop director after the Thursday evening event of 1988 September 22. Professors Tapan K. Sarkar and Sujeet K. Chaudhuri, both participants also of the NATO-ARW-IMEI'83, were chosen to replace Professor Pierre C. Sabatier (unable to participate due to illness in the family) in this function and for the frank and constructive report that was to be expected to be forthcoming particularly from them. They were assisted by Drs. Edward Moshang and Petro Baptista, who joined the workshop for the first time and whom they invited to assist them in this effort.

CONCLUDING REMARKS

As you know, there was a NATO workshop organized here five years ago at the same time by Prof. Wolfgang-M. Boerner on "Inverse Methods in Electromagnetic Imaging". That workshop was primarily theoretical in nature. From the papers presented at this 1988 workshop on Radar Polarimetry, the impression we obtained was that there had been significant progress made both in the advancement of theory and metrology, and especially in the development of hardware. We think the first workshop might have contributed in a significant way to this progress. For this apparent progress, we thank Mr. Lloyd W. Root for being the preacher in the USA, and Dr. Wolfgang-M. Boerner for being the crusader and "porte parole" in the rest of the world.

The polarization radar has now got a lot of sophisticated capabilities and it has become a very powerful tool, if utilized properly. So from a practical point of view, the theme of the second workshop has been just perfect. Practice following theory, since practice without theory is like a ship without a rudder, whithering in water and not knowing where it is going - (Leonardo da Vinci). The working discussion groups have been very useful and remarkably successful. Dr. Dag T. Gjessing and Mr. Leonard A. Cram, as you are aware, again performed the herculean task of getting the discussions group activities going and enticed them to come up with their own agenda about what are the critical problems areas, asking for immediate resolution, which turned out to be very similar to those proposed by the Planning Committee. It provided an avenue for participants to vent their opinions and educate others from their individual experiences so that little time is wasted in rediscovery of the wheel. We think the Working Discussions Group activities were and truly are a great idea in the manner those are exercised during these two NATO-ARWs. In the discussions group activities, the relationships between the cause (individual theories) and the effect (practical measurement results) were argued vigorously and that is the way it ought to be. For when we do not know the cause, we call it an accident; and clearly, we do not want to make everything an accident!

The scientific tours also added significantly to the technical content of this workshop. The tours were planned most diligently and organized in a highly professional manner and we were given the rare opportunity to have a glimpse of very sophisticated forefront technology at TST

(AEG) and at Carl Zeiss. The tours had an extremely high information content and were given by forefront researchers with excellent technical capabilities and also remarkable linguistic talents.

The cultural tours gave us the opportunity to have an indepth view of the history of this area. The wonderful thing is if we were to come here as tourists, we could not have seen more. For example, if we were here as tourists, we would have gotten only the venerable culinary carp dinner but would have missed the guided tour and the lovely music and history of Franconia. Even though, sometimes, Wolfgang extends the culture beyond the limit of analyticity, we know for sure that he has only good intentions and our welfare at heart, and that he desires to connect the past with the future by chosing Franconia, where he grew up, as an example.

In short, even though the workshop was very intense, there was a perfect mix of fun and work, and during the late night gatherings at the bar, where the stimulating intellectual intercourse revealed the compendium of radar polarimetry, we got to ruminate the pertinent daily events, including the Reforger Exercises.

Well, this workshop also revealed something else. It made it clear from some of the talks that there appears to be a lack of understanding of a great many interdisciplinary but also basic fields, and especially of detection and estimation theory. For example, the whole process of identification is a random process; it is not deterministic. Therefore, it should be treated as a stochastic process. Hence, it is not enough to say what the expected value of the result is, but what is the statistical variance. Variance offers a limit as to how far we can stretch the facts. For example, all the tanks that you have been seeing all around the Congress Center and Kurpark, have apparently killed several Germans and almost killed an American. Hence, it is possible to reach a conclusion that all these tanks around us are Russian! A finite variance would eliminate such a conclusion. In simple terms, variance provides certain confidence limits of the results. From some of the incomplete papers, one might get the impression that polarization diversity is a solution in search of a problem. For example, we saw lots of sexy pictures of what polarization diversity can achieve, but what we would like to know is after how much tweaking, fudging and so on we got that picture. We are absolutely sure that this was not on the first try! Our objective should be to get the mysticism out and the science in, and to assess what intrinsic polarimetric vector signal/image processing without additional image cosmetics can achieve!

Another problem area was reciprocity. It seemed to us that whether reciprocity is satisfied or not for a particular problem or data set depends on how well you have said your prayers. This is not the way! Reciprocity is like pregnancy. Either she is pregnant or not, there is no approximate pregnancy and hence either reciprocity holds or does not hold. Approximate satisfaction of reciprocity does not make any sense! This entire topic of reciprocity seems to need a face lift and by far is not a fully understood topic.

A third area of importance would be information about phase. Many papers described the intensity of the pictures as a function of polari-

zation in case we use the coarse Mueller-matrix averaging approaches for which we are completely ignoring the phase. However, there is also the phase information. Some of the authors, Professors Bringi, Boerner, Langenberg, Gjessing, Zrnic and Holt in particular, talked about the importance of phase. We think phase information should not be completely ignored as it might reveal some information on the phase and group velocity of the object.

A related problem area is the reduction of speckle. It has been shown how matched polarization supposedly reduces speckle. The presence of "speckle" in a picture is due to high or low relative intensities at a point. Now, matched polarization only maximizes a real function and, therefore, optimum matched polarization would not necessarily reduce the "speckle". However, change of polarization would change the contrast in the picture and more theory is necessary to predict the actual performance.

In short, there appear to be some weaknesses in the area of vector signal processing, detection and estimation theory and intelligent processing of these polarimetric data in spite of the great progress in other areas. Perhaps, we should ask Wolfgang to organize a third workshop to address these problems in more depth, since he has done such a magnificent job with the first two workshops.

In addition, we should move with time and address the pertinent practical issues of today to which radar polarimetry will contribute most profoundly. Namely, in the detection of extremely low observables in a dynamic complex background clutter in which all of the above issues will play an even greater role.

Again, as Len Cram concluded after the last NATO-ARW in 1983, the event would have been a huge success just as a conference. As a workshop, it was just like the first ARW, a splendid inter-disciplinary experience; it made participants of the previous workshop strengthen their interaction, for new-comers it provided an invigorating working environment, and it enabled them to make new acquaintance to many previously unknown colleagues in the same field. Most importantly, this second Advanced Research Workshop has demonstrated the rapid advances made in the development of inverse processing in electromagnetic imaging, and it has strongly contributed toward elevating radar polarimetry to a profound engineering science. In a next step, we will have to address its applications to the instanteous ranging, localization, detection, specification, imaging and identification of pollutants of any kind be it military, environmental or socio-economic in nature embedded within the terrestrial or planetary atmospheres, oceans and crusts. Thus, we request from the Planning Committee and the Workshop Director to organize a third ARW in about five years time after the elapse of this workshop in order to address these specific issues.

In conclusion, we thank everyone who has contributed to this lively and productive event. May we see you soon again — healthy and as research-invigorating as all of you were during this week — in Bad Windsheim.

IX-8 PREVIEW OF NATO-ARW-WPDR'93:

WIDEBAND POLARIMETRIC DOPPLER RADAR SENSING AND IMAGING for the instantaneous detection, ranging, imaging and identification of targets endangering and agents polluting our global planetary environment

Wolfgang-Martin Boerner

Abstract: In winding down the editing of the Proceedings manuscript, rather drawn out due to the integration of new important post-workshop contributions from both Eastern and Western radar polarimetrists, it was considered desirable due to the truly dramatic changes in world politics, the re-alignment of world powers, the resulting changing defense strategies and the emerging global environmental planetary crisis, to provide a post-summary of events leading to the preparation of a third NATO Advanced Research Workshop in this series on "Wideband Polarimetric Doppler Radar Sensing and Imaging: NATO-ARW-WPDR'93", to be staged again at the Kur-und-Kongress-Hotel Residenz, Bad Windsheim, Central Franconia, FRG during 1993, September 19-25.

1. INTRODUCTION: Historical Socio-Scientific Post-Analysis of the NATO-ARW-IMEI'83 and NATO-ARW-DIMRP'88 on Direct & Inverse Methods in Electromagnetic Wideband, High Resolution Polarimetric Sensing and Imaging.

In the past decade, during the preparation, execution and editing phases of these two workshops and their proceedings, we witnessed extraordinarily rapid technological advances, for example, in consumer goods production, hi-tech strike weapons development and in wide area military surveillance; however, often too much to the neglect of safeguarding our fragile planetary environment and cultural heritage. The first workshop took place at the height of the 'Two Superpowers Cold War' confrontation requiring the rapid development of 'hi-tech strike weapons' by utilizing complete electromagnetic vector wave target interrogation capabilities in high resolution radar sensing and imaging, which culminated in the advanced weaponry displayed in the NATO Reforger Exercises and in the Warsaw-Pact Counter-Maneuvers on opposite sides of the then existing Iron Curtain (FRG|GDR), precisely during the second workshop, as described in the DIRECTOR'S FOREWORD (prepared and completed in 1989 May!). For the first time, complete polarimetric high resolution sensor technology was tested, and our two workshops contributed strongly toward improving high resolution, wideband electromagnetic sensing and imaging for the rapid detection of highly camouflaged ('active RCS reduction') weapons systems, including surface-skimming cruise missiles, foliage covered armament and under-ground mines. However, the insanity of these maneuvers - measured on a global scale - invited our action and made many of us "crusaders for an end to the Cold War period". In pursuing this new challenge of finding a common denominator for more constructive co-existence by repeated counter-visits of remote sensing experts from the West (NATO, ANZAC, Liberated Asia, Pacific Rim) with those from the East (Soviet Communist Imperium, P.R. China & North Korea), another even more serious global problem disguised itself, namely, the flagrant neglect of environmental protection within Eastern countries far beyond the Great Lakes Environmental crisis of the early 1960's. In fact,

increased world-wide traveling clearly demonstrates that our global planetary ecology - in East and West alike - is being subjected to increasing non-sustainable stress and, in spite of some piece-meal often all-too-emotional efforts, is further deterioriating rapidly. No immediate end to this global environmental planetary crisis is in sight due to the ever increasing global population explosion paired with the quest for ever new resources, the unnecessary misuse and squandering of scarce resources by the rich and a 'justified greed' by the poor, awakening third-world countries, etc. Especially with the recent disintegration — occurring soon after our second workshop of September 1988 — of the Eastern European Socialist, the Soviet Imperialist and P.R. Chinese economies, it has become evident that the persistent environmental neglect of these regions resulted in the complete poisoning and almost irreversible pollution of its potable, industrial and recreational natural and artificial water resources. The heavily polluted lakes, rivers and ponds, in increasing numbers, are becoming "picture-book" examples of newly created breeding grounds of novel bacterial, fungal and viral diseases. For most of these newly created pests added to our global flora and fauna no immediate cures exist, and its global distribution is facilitated by a rapid increase in inter/trans-continental (pleasure) travel of the masses. As a consequence, environmental neglect in one terrestrial region will affect progressively and - in future - immediately all other far-distant trans-continental regions and no longer excludes Arctica and Antarctica.

2. **The Emerging Global Environmental Planetary Crisis: The Causes for Changes in Global Defense Strategies.** As many of us workshop participants witnessed during recent joint visits to "the East", is is not only the collapse of an obsolete consumer goods technology, of totally venerated industrial facilities, of the rigid ideologic system (Communist Party and KGB) which forced the USSR and its satellites to bring about the sudden mind-boggling changes in Global Defense Strategies! Certainly, the recognition by the USSR Academy of Sciences during the eighties of the severe seriousness of the environmental conditions most drastically impeding the future and current health and life of Soviet citizens, and its clear warnings to the Supreme Soviet of May 1989 has dictated the recent almost unreal removal of the iron curtain during the night of 1989 November 9/10, only one year after the Reforger Exercises at the height of the Cold War period which we participants of NATO-ARW-DIMRP'88 will never forget. In fact, the Supreme Soviet and its Army Chief of Staff were warned that however high, however deep the "iron curtains" be expanded, those cannot pose a barrier of containment to the "West-East/East-West" migration of environmental and sociological (drugs) pollutants, but that we are from here on into future dealing with a **"global environmental planetary crisis"** which must be combatted together and seen by all competing factions as our most important common defense issue, namely that of **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE"**.

Thus, as the awareness of the existence of a **'global environmental planetary crisis'** progresses, not only within the USA, the UK and all of NATO, but even within the USSR, a sudden **'HALT'** must be invoked in further increasing defense budgets to the detriment of safeguarding the environmental health of its people. Worldwide, we are hence coming to appreciate that we require **"Departments of Defense for the People from**

(i.e., all but not against one or other alien) **People"**, and that we - all together - must devise new ways and means of safeguarding and protecting our one and only precious and so fragile global planetary environment. It would be easy to add – since we met last - many more examples of the ongoing blatant attacks on our global planetary environment by irresponsible actions of the negligent rich (over-production of waste, export of contaminated waste for dumping in poor countries, and the most irresponsible universal suburban sprawl) and by the greedy poor (rain forest depletion) which are going to be forced on mankind with ever increasing intensity due to the uncontrolled population explosion, the major cause of global famines, environmental degradation and human misery.

Yet, another much more serious and truly dangerous terrorist attack on our global planetary environment was recently knowingly and willfully executed by igniting the 'oil-well torches' which constitutes the first true **MILITARY-ENVIRONMENTAL** connection on a global scale! It stands to reason that such acts of **"planned environmental piracy and terrorism"** could become a new **"environmental instrument of war and attack with long-lasting after-effects on culturally wealthy and environmentally healthy regions"** by the desperate splinter nations and slowly assembling militant remnants of the rapidly disintegrating Soviet Socialist Empire in the near future - (predictable acts of global insanity!)

As a result of these recent events, we find that the **"chicken-versus-egg"** problem of **"global environmental planetary defense"** versus **"the restructuring and reprioritization of resulting military technology needs"** was and still is dictated by the period of global environmental neglect exercised with equal irresponsibilities by the East and the West since the advent of the Industrial Age and more recently with increasing intensity within the Socialist Soviet Empire. It has become a global overriding issue which, paired with the recent terrorist assaults on our global planetary environment, has forced the two superpowers, the USA-versus-USSR inclusive allies, to initiate collaboration by terminating the Cold War period, and has also taught the once staunch adversaries to become close allies (if not immediately, so definitely in the near future) in order to safeguard our global planetary environment which requires such combined, well coordinated global action. As a consequence of the cognizance of new and common **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE"** priorities, the build-up of wasteful, costly weapons arsenals and redundant military forces - as observed so vividly during the Reforger Exercises by all participants of NATO-ARW-DIMRP' 88 - can now be drastically reduced, resulting in the saving of valuable **"defense dollars"** and **"defense rubles"** simultaneously. Of course, these sudden, very decisive cuts in military spending are effecting the **"conventional military systems research & development as well as military weapons supply industry"** most drastically. In fact, our previous enemies may have to become our **"most sought for friends"** of the future in order to protect the entire terrestrial natural ecology and man-made cultures from further blatant enviornmental terrorist attacks and destruction.

3. **THE QUEST FOR NEW TECHNOLOGIES FOR THE STRENGTHENING OF "GLOBAL ENVIRONMENTAL PLANETARY DEFENSE"**: Fortunately, the observed need for the down-sizing of conventional and nuclear weapons R&D&E, maintenance,

and supply is occurring precisely at a time when we require most urgently to address the issues of developing **"NEW ENVIRONMENTAL TECHNOLOGIES"** for safeguarding and defending our one and only global planetary environment:

> **THUS, the question to be raised is not how to find alternative markets for the excess capacity freed in defense brain-power, in defense R&D&E, and in the supply of defense technology; but - INVERSELY - it is the QUEST for identifying freed defense brain-power, vacant defense R&D&E and military garrisons, and the freed industrial facilities for developing the "NEW TECHNOLOGIES" for "GLOBAL ENVIRONMENTAL PLANETARY DEFENSE".**

In fact, the closure of obsolete defense facilities, the consolidation of redundant and self-perpetuating R&D&E laboratories, and the realignment of the freed integral defense excess capacity — in the West and the East alike — is long overdue and the entire process must be sped up, and reapplied, i.e., literally thrown against combatting the identified **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE THREATS"**. The sudden seemingly apparent over-abundance of excess capacity of the military sector as a whole is hence occurring precisely at a time of great urgency and all we need to do is to refocus, to redirect, to retune, and to re-establish priorities toward meeting the demands of environmental defense.

Development of NEW TECHNOLOGIES for "GLOBAL ENVIRONMENTAL PLANETARY DEFENSE": Certainly the relevant know-how in the pertinent technologies has been developed within our existing defense and space research centers and industries as relates to waste prevention and treatment (toxic and radioactive); reduction of air/water/soils pollution created by obsolete technologies; carbon-based transportation and energy generation; misguided agriculture (over-fertilization, over-use of toxic pesticides, etc.); site clean-up activities; the instantaneous detection of environmental terrorist attacks or accidental spills - from space, air/sea-borne or land-based sensor platforms; and the instantaneous isolation of such hazard zones from its immediate surroundings and the global environment from a planetary perspective. The capabilities of developing all of these technologies exist although with the caveat of being strictly applied to a military charter. But, technology is technology whether applied to military or civilian needs. Whereas, during the late 1960's to early 1980's, NASA's space technology transferred to consumer goods; **during the 1990's and beyond we hopefully may witness the transfer of non-sensitive military technology for solving environmental problems and for safeguarding our shared global planetary environment and cultural heritages.**

International Realignment and Safeguarding of Sensitive Environmental Technology: The development of new technologies in **"Global Environmental Planetary Defense"** will become a major multi-billion dollar international business. Hitherto, the USSR, its former allies and most of the developing and third-world nations completely lack the **"know-how"** in this vital technology for future sustainability of life on this earth. Thus, it is to be anticipated that a very cut-throat **"environmental technologies warfare"** similar to that experienced by our "Western" car, electronics consumer goods and computer industry will emerge. This, in

turn, will require preventive action. Although, there does not seem to exist another viable path but to combat this problem of **"Global Environmental Planetary Defense"** on an integral super-power approach, (i.e., hand-in-hand together with our near-past most dangerous adversary, the USSR), we must be on alert and protect our **"New Environmental Technology"** from a **"sell-out of our still existing edge"** to other aggressive nations, which could be tempted to misuse the gained knowledge and apply it inversely to developing even more sophisticated weapons for executing environmental acts of terror. Also, we need to develop immediately improved instantaneous discrimination methods of distinquishing between "friendly versus hostile fire (re allied casualties during recent Kuwait war)". It is precisely these issues which also must be tackled in conjunction with combatting **"Global Environmental Defense Threats"**. Definitely, we must walk the tight rope of addressing these newly emerging global versus nationalistic defense threats together with our recent adversaries, the USSR and its former East-Bloc Satellites, and all other mature nations.

In context with our two previous NATO-ARW's, the third workshop, planned for September 1993, thus, as a consequence of above considerations, invites full participation of experts from the past **"WEST"** versus **"EAST"** to meet together in Bad Windsheim, Germany, by addressing specific **"electromagnetic environmental sensing and imaging topics"** of **"GLOBAL ENVIRONMENTAL PLANETARY DEFENSE"** which constitute some of the most urgent, unresolved problems of wide area terrestrial surface surveillance for the early mitigation of global threats.

4. THE INSTANTANEOUS DETECTION, RANGING, SPECIFICATION AND IDENTIFICATION OF LOW OBSERVABLES AND OF POLLUTING AGENTS IN OUR TERRESTRIAL SURFACE ENVIRONMENT: One of the most pressing issues in **"Global Environmental Planetary Defense"** is **"Wide Area Global Environmental Surveillance"** with the ultimate goal of the **"instantaneous detection and/or prediction"** of major impeding environmental catastrophes which need not be created necessarily by man himself but by the ever-active deep-earth internal forces which affect our biosphere by such natural catastrophes like earth/sea-quakes with related tsunamies, by volcano-explosions and by major global weather changes also being induced by global earth-internal causes. Thus, we need to explore the specific "instantaneous disaster-prevention and mitigation" capabilities of the entire electromagnetic spectral regions in wide-area global environmental surveillance including the **lower ULF (below 10^{-3}Hz:** Earth-internal and coupled extra-terrestrial "gravitational sources" (with periods of days, weeks, months and years) which could trigger major global weather/climate changes; which if detected early enough, could allow for sufficient time for some wide area disaster mitigation); **the upper ULF and ELF (10^{-3}Hz - 10^{3}Hz:** earth/sea-quake and volcano activation precursor radiation; which if detected early enough, could lead to "well planned, deep earth disaster mitigation"); **ELF-LF (1KHz - 1MHz:** detection of otherwise "low observable objects" traversing the ionospheric fluid layer or skimming along the terrestrial surface which create acousto-electromagnetic, coupled terrestrial-ionospheric resonance phenomena); **HF-VHF (1MHz - 1GHz:** Ultra-wideband detection of low observables embedded in noisy background clutter, plus, passive wide area environmental security surveillance in-

cluding penetration capabilities such as through foliage and into lossy soils); **M-Sub-MM** (about 1GHz - 100GHz: High Resolution target sensing and imaging in a wide area terrestrial boundary layer environment); **MM-IR** (20GHz - 100THz: Molecular spectroscopy and radiometric imaging); **IR/OPT/UV** (10THz - 1QHz: High resolution lidar sensing and imaging in atmospheric and oceanic environments (blue-green laser); further advancement of hitherto unresolved/undiscovered phenomena in polarimetric bionics and their bionic systems implementation into the development of improved INSTANTANEOUS electromagnetic sensor systems).

During the past decade the development of the required relevant High-Technology base was in principle pioneered in many pertinent disciplines such as in global multi-channel bulk data signal & image sensing, neural networking, parallel computer-processing, and in spectral data fusion, which now allows us to approach the development of intelligent self-reliant automated sensors in

"HIGH RESOLUTION INSTANTANEOUS DETECTION, SENSING, SPECIFICATION, IMAGING AND IDENTIFICATION" of "GLOBAL ENVIRONMENTAL PLANETARY THREATS",

so that "disaster mitigation" procedures may be enacted in time for regional and global disaster reduction and prevention. It is the objective of the forthcoming third workshop: **NATO-ARW-WPDR'93** to address the **"Direct and Inverse Problems"** associated with **"Wideband Polarimetric Doppler Radar Sensing and Imaging within the pertinent spectral regions"** in this rapidly emerging new scientific discipline.

The outlay of the daily program and of the topical sessions will closely resemble that of the two previous workshops. However, during the forthcoming WPDR'93 workshop, main attention will be paid to an all-engulfing 'extra-wide-band' approach together with various modes of spectral data fusion of separate "wideband spectral sub-domain solutions" which were loosely identified above. Specific details of the program will be provided by early 1993.

5. MEETING PLACE & DATE, ORGANIZATION & PROGRAM COMMITTEE, INTERNATIONAL EXPERT PARTICIPATION: This third NATO-ARW is planned again with a five year delay so that the presentation of truly new advances is guaranteed; it is planned to be executed within the same, but further expanded Kur-und-Kongreß-Hotel Residenz, Bad Windsheim, Mittelfranken, because of its relative seclusion from the main European tourist arteries. The third week of September 19-25, was chosen again in anticipation of the pleasant and mild late summer/early fall weather of extended Main-Franken. In spite of the recent integration (1990) of the former German Democratic Republic in the Federal Republic of Germany, Franconia countinues to present the historic and cultural heart of the emerging Germany of the early 1990's with Mittelfranken (Central Franconia) and Oberfranken (Upper Franconia) establishing the historic links between Bavaria and Prussia through their pre-napoleonian margravedoms of Brandenburg-Ansbach and Brandenburg-Bayreuth, respectively. It is objective of the scientific-cultural program to highlight the changes that have occured since the waning of the Cold War in context with the theme of our third workshop. Thus, whereas during NATO-ARW-IMEI'83 scientific/cultural events were centered on Central Franconia

(Nürnberg-Erlangen-Bamberg) with program-termination in Würzburg, the heart of Main-Franken mainly dealing with direct and inverse methods in electromagnetic imaging; and, during NATO-ARW-DIMRP'88 on the West-southern extension (Rothenburg-Dinkelsbühl-Oberkochen-Ulm) with program termination at DLR-Oberpfaffenhofen near München, the capital of Bavaria with prime emphasis on high-resolution polarimetric sensing and imaging; the scientific-cultural events of the third NATO-ARW-WPDR' 93, are directed toward the East-northern cultural extension of Central Franconia culminating in Berlin-Brandenburg recently chosen to become the new capital of the 'United Germany' after the "iron wall" was torn down (1989) and removed (1990). The Wednesday ('93 Sept. 22) scientific-cultural event of WPDR'93 includes planned visits to Bayreuth (FESTSPIELHAUS of Richard Wagner, the baroque opera and the Erimitage), together with a scientific tour of the deep-earth drilling project (10-12 km deep) at near-by Windisch-Eschenbach for exploring deep-earth environmental forces. Separately, a visit of the Markgrafenschloss Ansbach is planned in order to highlight the existing 'Prussia-Franconia-Bavaria connection', before leaving by Special busses for Berlin, on late Friday evening, after the banquet. We plan to terminate the NATO-ARW-WPDR'93 at one of the new additions to the German Aerospace Research Establishments, the DLR-Research & Development Center in Remote Sensing of Planetary Hydrospheres, Crusts and of Interior Planetary Chemistry/Geophysics at the DLR-Forschungszentrum Berlin-Adlershof in former East Berlin (the former GDR, Academy of Sciences, Cosmos Research Institute). Whereas, the scientific visit to the KTB (Kontinentale Tiefbohrung in der Oberpfalz) Windisch-Eschenbach is programmed to clarify subtleties of lower ULF electromagnetic sounding of deep earth forces, the visit to Berlin-Adlershof at the Eastern outskirts of the new capital of eastward-extended FRG, is most essentially directed toward exploring the development of intelligent sensors in the upper spectral regions for the instantaneous detection, specification and identification of natural and 'cultural' (induced by living beings) environmental phenomena and hazards via electromagnetic remote sensing from space. Both projects constitute international East-West research interactive programs, supported not only by 'BMFT/BRD' (the-Federal German Ministry of Research & Technology) but also by all other NATO-member countries, Japan, Eastern European countries and by the USSR Academy of Sciences including the BICER (Baikal International Center of Ecological Research), Deep Drilling & Deep Lake Sounding projects.

In light of the recent East-West rapproachment and of the truly international character of research in "global environmental planetary defense", the organization and program committees have been slightly enlarged to include expertise from the Asia-Pacific Rim and the former Soviet Socialist Empire which also is reflected in the list of invited international expert participants as will be disclosed in early 1993. Participation in NATO-ARW-WPDR'93 is mainly by expert invitation and limited to about eighty selected active contributors plus a few observers.

In conclusion, this third NATO-ARW-WPDR'93, in continuation of NATO-ARW-DIMRP'88 and of NATO-ARW-IMEI'83, is to promote the advancement of a rapidly emerging "Global Environmental & Cultural Planetary Defense" science and technology.

FROM MILITARY TO PLANETARY ENVIRONMENTAL DEFENSE: The Challenge of the Next Century, and a Viable New Role for the U.S. Military in an 'Environmental Planetary Defense Initiative' on a Global Scale

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ABSTRACT

Civilization as we know it is threatened by environmental degradation on a global scale which, if continued unchecked, will soon reach a critical mass that will devastate the Earth's ecological life support systems just as surely as could a full scale nuclear war. We summarize first-hand observations of the current ecological situation in Eastern Europe and around the world. We report on critical situations such as new diseases, the water supply and its contamination that have come to light only in recent years.

We find that our greatest threat today is not from other nations trying to conquer us, but from our own capacity to destroy our environment and with it ourselves along with our planetary flora and fauna. Indeed, this is the greatest enemy of our times, one that we need to recognize and fight before we lose a battle that we did not foresee. To counter this imminent threat, we propose a new post-war role for the US military in a global environmental defense initiative in which our military capabilities would be restructured into a planetary environmental defense force.

1. BACKGROUND

The War Era, which began with the rise of fascism in the 1920s and which has only now ended with the apparent collapse of Soviet Communism, has left the former Soviet empire, including Eastern Europe, as well as most of the Third World on the brink of both economic collapse and environmental disaster. The lifting of the iron curtain has revealed a shocking history of environmental neglect and ruinous agricultural, industrial and military practices. The Chernobyl incident was but the tip of a very dirty iceberg and is a portent of latent disasters waiting to happen. In fact, many of the truly polluted agricultural and devastated industrial regions of East Germany, Czechoslovakia and primarily Southern Poland and Romania, as well as the USSR, have become 'picture-book examples' of newly created breeding grounds for novel bacterial, fungal and viral diseases that attack humans, flora and fauna alike. For most of these newly created pests no immediate cures exist, and their global distribution is facilitated by the rapid increase in inter/trans-continental travel. Thus, environmental neglect in one terrestrial region will affect progressively and - in the future - immediately all other far-distant regions.

The former Soviet empire still threatens us, not militarily, but ecologically. Rumania, for example, faced with a choice between continued operation of its obsolete Chernobyl-type power plants and near shutdown of its electrical power grid this winter has chosen to continue operating dangerous reactors that threaten the heart of Europe, though German technical assistance has somewhat alleviated the dangers. Less dramatically, toxic wastes continue to leach out of countless military and industrial dump sites into international waterways, and dangerous discharges from obsolete industrial facilities continue to cross the old iron curtain unabated. Estimates for cleaning up obsolete military-industrial facilities in the US, such as the Rocky Flats facility, run to deca-billions of dollars over the next several decades. For the USSR, we must assume that clean-up will at least be an order of magnitude greater. We must concern ourselves not only with the disposition of the former USSR's nuclear weapons but also with that of the plutonium when they are decomissioned. Plutonium, aside from its use in weapons is an extremely long-lived and highly toxic substance that cannot be

allowed to escape into the environment under any circumstances.

In the former Soviet Union and Eastern Europe, the democratic revolution is far from complete. Many areas have had little or no exposure to democracy, indeed in European Russia itself, most people are more interested in their next meal than in democratic ideals. We must not forget that, just as communism was ultimately toppled by its economic failures, economic misery can also bring down democracies as it did in Germany in the 1930s. With their economies in sharp decline and burdened by enormous external debts these regions face growing ethnic and political tensions that could erupt into disastrous civil wars which, if fought with nuclear or chemical weapons left behind by the Soviet army, could permanently reduce the population carrying capacities of huge regions. The Russian republic, without external assistance, cannot be counted on to stabilize the situation. In fact, Russia herself, which contains eighteen autonomous regions, is now in the process of fragmenting along ethnic and cultural fault lines.

The military units returning to their home territories constitute the building blocks of territorial militias, which may not necessarily be under democratic control. At the present, many of these returning units, which always were retained ethnically unique and not mixed with units from other republics or autonomous regions when deployed elsewhere - thus further elevating ethnic differentiation - are demoralized, especially those returning from Eastern Europe and Eastern Germany in particular, and currently are ill-prepared to fight. But, if economic conditions within their ethnic regions further deteriorate, intra-regional civil wars for the control of food, energy and also industrial resources could break out, not only similar to, but much worse than what is now being experienced in Yugoslavia. Such civil wars would generate not only economic but also environmental disasters of unprecedented proportions that could leave additional huge areas of the former USSR with drastically reduced population carrying capacity for decades to come. In turn, such wars could unleash hordes of starving refugees heading west, and will strongly add to the emigration pressure built up relentlessly during the past seven decades during which escaping or emigrating from the USSR was next to impossible. It also needs to be mentioned here that, currently, the expected number of disgruntled Soviet citizens bent on emigration is of the order of several deca-millons. Thus, we of the free world, had better do everything possible to avoid likely migration tsunamis which might inundate us in the foreseeable future.

In the Third World, exploding populations and unregulated industrialization are stressing the environment to the breaking point. Events in these regions will have global impacts that cannot be ignored by the developed world. If steps to improve the situation are not taken soon, waves of desperate refugees from economic and environmental disaster areas could soon wash onto our shores. The massive Vietnamese boat emigrations are but a prelude to what could be in store. We must recognize that unchecked population growth initiates a vicious cycle of poverty and environmental degradation that must be stopped.

The threat to life and civilization as we know it is no longer Soviet expansionism but the impending global collapse of the Earth's ecological life support systems brought about not only by pollution and environmental exploitation but also by the disruption of the Earth's physical, chemical and biological cycles not only in the former Soviet empire and the third world but also in the developed world, where energy efficiency and resource recycling lag far behind the growth in consumption. The US and its allies in concert with their former adversaries must now redirect the enormous resources and technical expertise that have up to now been absorbed in military defense to counter ing and reversing this trend.

To forestall such environmentally induced economic, social and political collapse, not only in the Soviet Union, but also in the Third World with subsequent discharges in the form of migration tsunamis of hitherto unprecedented numbers of ill-prepared resettlers, we must recycle man-power that was formerly absorbed in the world's militaries and military industries into a new international environmental and economic peace corps of professionals! It is, indeed, becoming a high risk situation in the USSR where demobilized soldiers are returning home only to be unemployed. Also, the US must face the fact that employing and housing troops returning home from Europe and Asia,

unless recommissioned elsewhere (Mid-east), could end up as a social burden. Thus, world-wide, a search is on for changing our established patterns of co-existence. We require a new global mission to provide new incentives for our industries to re-tool, to stop the manufacture of products which are obsolete, and replace them by environmentally safer ones. An **'International Environmental and Economic Peace Corps of Professionals'** that would embrace US, European, Soviet, Japanese, Chinese and Third World youth could convert this human burden into a human asset. If the Soviet Union is to successfully establish a functional market economy, it will need to regenerate millions of enterpreneurs and managers, who were liquidated in the Stalin era. More than money, they need the expertise that could be supplied by this new International Environmental and Economic Peace Corps of Professionals for instilling the thinking and action approaches based on democratic values and a better understanding of various market economies. They will have to create a new form of market economy, more likely to be effective, differing from our free-market system. During the current global transition period, a substantial number of industrial experts, who otherwise might remain unemployed, should be enticed to join this movement. The common mission is then to generate new environmentally cleaner industries in accord with environmental planetary defense policies, which then would provide a truly wide spectrum of new long-lasting and more permanent employment opportunities on the basis of strong industrial growth; i.e., environmental defense requires economic perestroika.

2. THE ROLE OF THE US MILITARY IN AN ENVIRONMENTAL DEFENSE INITIATIVE

Only the US and its allies, particularly the European Community and Japan, have the industrial, financial and technical resources to initiate a program to build a sustainable world economy that operates in harmony with the planetary environment. The US, which bore the brunt of military defense as the leader of the free world especially during the Cold War Era, now has the historic opportunity to assume leadership of a global environmental defense initiative embracing both our allies and former adversaries. As the last super-power only the US has the international credibility to initiate and orchestrate a program of environmental rescue and rehabilition on a global scale.

The US military operates a network of bases that girdle the globe, it commands highly trained man-power that can rapidly deploy to virtually any point on the planet, operates advanced remote sensing and monitoring systems that can observe virtually any point on Earth, and it can marshal world class technical, engineering and scientific manpower on a scale unsurpassed by any other organization in the world. These are precisely the capabilities that must now be brought to bear to rescue our planet from ecological disaster. By rearranging and adapting building blocks that are already in place, the US can restructure its military forces into a global environmental defense force. It would be a grave mistake to dismantle this capacity because there simply does not exist any other framework that could effectively wield these resources.

Military monitoring systems must now be redirected to detect environmental disasters, both man-made and natural. Had the appropriate sensors been in place, the Chernobyl incident could have been detected within minutes or hours of its occurence instead of the several days that elapsed. Illegal discharges of toxic wastes can now be quickly detected and traced to their sources. Moreover, the enforcement of international treaties against toxic waste dumping in the oceans and for the protection of environments, such as the Arctic and Antarctic, from illegal exploitation, bans on illegal weapons tests or international fishing agreements implies the need for advanced remote monitoring systems backed up by rapidly deployable enforcement and cleanup teams when violations or accidents are detected.

Environmental defense, as recent events in the Persian Gulf vividly illustrate, must also include the tools needed to neutralize acts of environmental vandalism. We could have used reconfigured missiles and bombs to rapidly and accurately deliver fire retardents to oil wells before they blazed out of control. These could also be used to fight forest fires in remote and sensitive environments such as the Amazon. Environmental defense may also require armed forces to stop the international trade in illegal drugs ('social pollution'). In addition, we must act to prevent drug use at the source. Some of the decommissioned military facilities in the US and perhaps overseas,

could be re-aligned for use as rehabilitation centers, where drug-addicts could be re-educated and set to perform useful labor for improving our environment (for example, a 1930's style Civilian Conservation Corps). South American Andean and rainforest eco-systems are being devastated by the land clearance for coca production and by dumping of unknown thousands of tons of toxic solvents for processing it. New sensor technologies for the instantaneous detection and monitoring of these sites are now required.

The pollution of our water resources has often been overlooked. Fresh water, which tends to attract wildlife and human settlement, is particularly at risk. Recent studies have shown that continental aquifers are on the average far more shallow than previously thought and as a result estimates of global potable water reserves must be revised downwards to 40% of previously believed levels. Underground aquifiers are imperiled by pollutants leaching from toxic waste dumps and perhaps more insidiously by runoffs from our urban streets and highly trafficked highways wear-off from vulcanized tires (lead, sulfur, cadmium, vanadium, etc.) and leakages from vehicles (ethylene glycol, brake fluid, battery acid, etc.) and farms (fertilizer and pesticides). Leaking waste dumps are identifiable and repairable, but the latter non-point source pollution can only be eliminated by reforming agricultural practices and by changing the way we live. Unlike surface waters, water turnover in underground aquifers ranges from tens to hundreds of years. Once polluted, they could well be unusable for many generations. There are only a few large surface reserves of potable water such as the Great Lakes of North American and Lake Baikal in Siberia, and the major terrestrial rivers, especially in northerly regions. Both are threatened by toxic run-offs in their drainage basins created by industry, transportation, agriculture and forestry.

Much of the increase in agricultural runoff in the US is a result of a forced economic collectivization of family farms. Cheap food policies and massive and misguided government subsidies (for example subsidized water in the West) have created a system in which short-run costs drive the price of food. The real price of food will be paid by the next generation. Millions of family farms have been taken over by agro-concerns that dump tons of fertilizer onto the land to replace wind - and water-eroded topsoil, and who recklessly spray hundreds of kinds of pesticides to squeeze the maximum profit out of the land. It is ironic indeed, that just when the land in the former Soviet sphere is being privatized mainly because of the after-effects of collectivization, we are collectivizing with the result that also in the US an ever increasing number of rare species of plants and creatures becomes extinct.

Much damage has already been done and we must face the fact that in the next century we will have to turn to desalination to meet our potable water needs. This will require that basic new technologies be rapidly brought from the experimental to the industrial stage, additional major enviromentally clean energy resources be discovered, and that extensive trans-continental networks of potable water pipelines be developed, for example, by the US Army Corps of Engineers, which could one day out-number the existing oil and gas pipelines in the US and elsewhere. But it is unlikely that desalinated water can replace fresh water in nature for sustaining a healthy wildlife, flora and fauna on a global scale and, therefore, we must be ever more on the alert to protect our terrestrial large lakes, aquifers and glaciers from contamination.

Reduction of heavy metal toxic pollutants may require the active redesign and re-tooling of our car and tire manufacture industries, worldwide including the pertinent Japanese and German industries. Also, in the future, the design of roads and especially heavily trafficked interstates will need to be changed to include catchment facilities for collecting the run-off of wear-off from tires and leakages from vehicles, etc., which poses a truly enormous task for the entire global community. The US ought to take the lead in approaching these complex environmental transportation safety questions because we are still the top ranking car owners and users, as well as road builders globally. In the developed world, but especially, in the US, the prices of products do not include the "environmental costs". The proper "real" price of gasoline in the US is at least three to four times what we actually pay for it. For example, in Germany, gasoline prices are now four times the US cost in order to build environment friendly 'autobahns' starting to accommodate said run-off catchment facilities. In short, environmental defense requires economic perestroika, which also implies, in

general, that we must find new market mechanisms that discourage the manufacture of environmentally harmful products (leaded gasoline, diesel, standard vulcanized tires, etc.), and which promote the production of environmentally friendly ones.

It is our own bodies of potable water resources together with our oceans and polar iceshelfs which are currently under the most brutal attack by man. This entire global issue of **"Environmental Planetary Defense"** must become an integral part of the US Department of Defense, i.e., the precious defense dollars freed from the consolidation of obsolete defense facilties, out-moded R&D, and outdated defense technology must be applied in a well-focused approach to combat these newly emerging threats of environmental piratism and warfare. Indeed, as regards to the safeguarding of our coastal waters and regions, the ocean's marine fauna and flora, and especially the ocean bottom, it is our view that the US NAVY should be commissioned to assume major active responsibilities in wide area surface, sub-surface, and ocean bottom and coastal water/regions surveillance. Thus, in our opinion, the role the US NAVY should play, in particular its Naval Laboratories and Centers is to address the global issues of **environmental planetary defense** for the future **global preservation and safeguarding of our coastal waters and regions, the ocean's marine fauna and flora, and especially the ocean bottom** plus the terrestrial large lakes, the arctic/sub-arctic glaciers and of the transcontinental aquifers.

3. BASE CLOSURES AND RE-ALIGNMENT OF MILITARY & INDUSTRIAL FACILITIES

During the ongoing base closures and re-alignments of military and industrial facilities, in the West and East alike, we must identify those garrisons selected for closure which are ideally suited for accommodating military as well as industrial R&D&E (Research & Development & Engineering) functions in coordination with the realigned and freed industrial excess capacity, so that they can be commissioned for global reuse toward Environmental Planetary Defense committments.

For example, the military garrison at **FORT SHERIDAN, LAKE COUNTY, ILLINOIS**, is such a facility which was selected for closure; and in this case, it is imperative to recommission a substantial part of **Fort Sheridan** *to house a:*

"GREAT LAKES INTERNATIONAL CENTER FOR ENVIRONMENTAL, ECOLOGIC, AERONOMIC & CLIMATOLOGIC RESEARCH, EDUCATION, POLICY & ARTS IN A MARITIME CONSERVATION AND LAKEFRONT RECREATION PARK: THE FORT SHERIDAN GREAT LAKES CENTER".(1)

This re-use project needs to be achieved in coordination with the freed regional excess capacity of military and industrial facilities which together with academia could collaborate to establish an urgently required **'Graduate Research and Education Center'** for generating the desparately required new class of young multi-disciplinary environmental scientists/engineers. A **'Consortium of Midwestern and Great Lakes Institutions of Higher Education and Research'** ought also to be, in our opinion, established in close collaboration with the Scientific and Educational Research Offices of the US Department of Defense (AFOSR, ARO & ONR) to consider establishing an **'Educational Research Unit'** within the center campus of **FT. SHERIDAN** for the advancement of environmental education and environmental curriculum content on all levels - primary, elementary, secondary, graduate, post-graduate, post-doctorate and adult - in Great Lakes climatology, ecosystems, marine and lakeshore coastal ecologies, and on the interconnection of the mid-western US aquifers (Ogalala, Mississippi, Niagara, etc.).

It has become commonly accepted by many educators and professionals that our US youth seem rather bored, aimlessly drifting, and that we require a new educational mission similar to the post-sputnik goal of "placing man on the moon" but squarely footed on a more scholastic approach. This time, we need to deal with a very realistic, down-to-earth problem; and, what more suitable mission could there be but in generating enthusiasm and a renewed basic educational drive by placing much higher scholastic priority on global issues of 'environmental planetary defense', and also by overhauling our entire educational system at all levels and ensuring that sufficient environmental content is included in the curricula so that future generations can search for ways and means of living in an healthy terrestrial environment instead of having to clean up the mess we left behind. Although the main emphasis is currently placed on reduc-

ing toxics and other environmental contaminants, we also need to emphasize the threats to planetary flora and fauna, and to a healthy global environment, such as the loss of the quality and quantity, and genetic diversity, of wildlife habitat, plant and animal extinctions. The entire issue of comprehensive land-use planning, the need to limit suburban sprawl and associated deforestation, and to reduce the total size and demands of the human race need to be interwoven much deeper into the curriculum on all levels. Our children and students must be made aware in very clear terms that our current capacity to degrade and destroy our planetary resources is made possible by our recent technological developments and products and the toxic and nuclear wastes they create. We need to address these problems from a broader and deeper scientific basis, in a highly strengthened scholastic approach, to find a compatible ethical versus technical solution for man, our flora and fauna, to sustain life on this earth.

An invaluable asset in a global environmental defense initiative are our hundreds of domestic and overseas military bases, many of which have been selected for closure and facilities re-alignment. Instead of simply abandoning them, they should be converted to planetary environmental defense and research establishments. The future of US bases in the Phillipines is now being debated. The Naval base on Subic Bay is ideally situated to monitor the Southeast Asian environment as well as to study tropical forest, coastal and marine ecosystems, but later if not sooner we will lose this facility if we insist on operating it as a military base. A redefinition of its mission as an environmental research and defense facility, especially now after the recent devastating eruption of volcano Pinatubo, would win goodwill on all sides of the political spectrum and support for still dangerous Communist guerilla elements could all but evaporate. Many Southeast Asians would applaud a new non-military US role in Asia to counterbalance their growing economic dependence on Japan.

In Japan, US bases occupy valuable land resources and the US military presence is detested by most citizens though grimly tolerated as an increasingly unnecessary evil ('ken-bei'). Sooner or later, Japan will find a way to get rid of them. If these bases were turned into research facilities, however, the Japanese government would gladly support in part or wholly the costs of their operation. While Japanese corporations have established footholds and spheres of infuence within the US scientific and engineering community, not to mention its economy, there are very few "real" US research establishments in Japan. Japan has a huge cadre of people who speak our language, understand our markets and know our political and social system, if not inside-out, at least from the outside! This Japanese cadre outnumbers similarly knowledgeable Americans and Europeans by at least several thousand to one. US bases in Japan, with a redirected mission, could thus serve as valuable taproots into Japanese technical and scientific expertise as well as its markets and provide a training ground for our engineers and scientists who must increasingly compete head on with Japan. A new environmental consciousness is arising in Japan, but most Japanese are disgusted by their government's environmental policies and many look to the US for inspiration. It is ironic that much Japanese-made equipment for pollution control and alternative energy, (e.g., wind and solar) enjoys a larger market in the US than in Japan itself. A bold proposal to redefine the mission of the US bases would raise US credibility and its political stock overnight. Similar recommendations and comments apply to US bases in Germany. Germans, whose level of environmental consciousness is perhaps the highest in the world, would applaud a new direction toward environmental defense for the US military. With a single strike, both simmering ultra-rightism, as well as remnant communism could be neutralized and discredited.

4. NATIONAL AND GLOBAL ECONOMIC RESTRUCTURING

The environmental defense initiative must necessarily be a multi-faceted effort. We must also restructure our civilian economy. Entire industries need to be re-tooled to meet strict emissions standards and to produce products that are truly in demand, i.e, can easily be recycled while reducing energy consumption. While this will be a burden in the short run it will create new jobs and lower production costs. We must make a major commitment to developing clean and renewable energy resources. Although this effort cannot be unilateral and must be developed in concert with our trading partners

neither must we allow environmental standards to be reduced to the lowest common denominator. Advanced remote monitoring systems can now detect industrial emissions above agreed levels and products produced in violation of environmental accords can be barred from entering otherwise free markets.

Scientific and engineering expertise in the US defense research establishment must now be redeployed to develop the needed technologies. While we must continue to safeguard valuable technologies more 'glasnost' in the defense research is called for facilitating its transfer to the industrial and academic sectors as well as to other environmental agencies of state and federal governments. Recently, for example, we learned that the adaptive optical system and high power lasers developed for SDI could have obviated the need for the visible light spectrum part of the Hubble Space Telescope. This technology with its obvious civil and industrial applications was far too long kept under wraps. One of the most pressing issues in Environmental Planetary Defense is Wide Area Global Environmental Surveillance with the ultimate goal of the instantaneous detection and/ or prediction of major impeding environmental catastrophes which need not be created necessarily by man himself but, which may also arise from the ever-active deep-earth internal forces which affect our biosphere by such natural catastrophes as earth/sea- quakes with their related tsunamis, by volcano-eruptions and by major global weather changes also being induced by global earth-internal next to solar causes. Thus, we need to explore the specific **"instantaneous disaster-prevention and mitigation capabilities of the entire electromagnetic spectrum for wide-area global environmental surveillance"**[2], including: (i) **the lower ULF** (below **1mHz**: Earth-internal and coupled extra-terrestrial "gravitational sources" (with periods of days, weeks, months and years) which could trigger major global weather/climate changes; which, if detected early enough, could allow for sufficient time for some wide area disaster mitigation); (ii) **the upper ULF and ELF** (**1mHz - 1KHz**: earth/sea-quake and volcano activation precursor radiation; which if detected early enough, could lead to "well planned, deep earth disaster mitigation"); (iii) **ELF-MF** (**1KHz - 1MHz**: detection of otherwise "low observable objects" traversing the ionospheric fluid layer or skimming along the terrestrial surface which create acousto-electromagnetic, coupled terrestrial-ionospheric resonance phenomena); (iv) **HF-VHF** (**1MHz - 1GHz**: Ultra-wideband detection of low observables embedded in noisy background clutter, plus, passive wide area environmental security surveillance including penetration capabilities such as through foliage and into lossy soils); (v) **M-Sub-MM** (**about 1GHz - 100GHz**: High Resolution target sensing and imaging in a wide area terrestrial boundary layer environment including polarimetric doppler radar and satellite IR imagers deployment for the sensing of severe storms and hail for relevant disaster prediction and warning); (vi) **MM-IR** (**20GHz - 100THz**: Molecular spectroscopy and radiometric imaging); (vii) **IR/OPT/UV** (**10THz - 1QHz**: High resolution lidar sensing and imaging in atmospheric and oceanic environments: blue-green laser). During the past decade the development of the required relevant high-technology base was, in principle, pioneered in many pertinent disciplines such as in global multi-channel bulk data signal & image sensing, neural networking, parallel computer processing, in photonic signal/image transfer, and in spectral data fusion, which now allows us to approach the development of intelligent self-reliant automated sensors to be deployed in space and on surveillance aircraft (AWACS) in **"HIGH RESOLUTION INSTANTANEOUS DETECTION, SENSING, SPECIFICATION, IMAGING AND IDENTIFICATION" of "GLOBAL ENVIRONMENTAL THREATS"**[2], so that "disaster mitigation" procedures may be enacted in time for regional and global disaster reduction and prevention.

Further, promotion of these global concepts of **ENVIRONMENTAL PLANETARY DEFENSE**, will strongly benefit the future solidification and strengthening of our integral defense R&D&E as well as that of the pertinent, highly refocused, defense industry. Concurrently with the advent of recognizing the global need for Environmental Planetary Defense, there is also a strong and rapidly growing national/international environmental ethic contributing - though slowly but yet steadily - to the growth of environmental legislation and, for example, the participation of DOD/DOE in the demand for the clean-up of contaminated sites on local, regional, national as well as global scales. In fact, the Soviets have at long last recognized that however high, however deep the

iron curtains will be expanded, those cannot pose a barrier or containment to the WEST → EAST/EAST → WEST migration of environmental and social pollutants but that we are from here on into the future dealing with an environmental planetary defense issue which must be combatted together with all competing factions on a global scale! Hand-in-hand with our former adversaries, the USSR, the reprioritization of valuable defense dollars and defense rubles toward meeting the global demands of ENVIRONMENTAL PLANETARY DEFENSE will grow, and if our current world order still persists must absorb more than 50% by the year 2050 of the respective total active defense budgets. Worldwide, we are coming to appreciate that we require, in the future, **"Departments of Defense for the People from the People** all including but not one against other alien-nations),"[2] and that we must altogether devise new ways and means of safeguarding and protecting our planetary environment, i.e., no longer can we afford the proliferation of Balkan-State-like squabbles.

5. BENEFITS AND SUMMARY

The US, the world's remaining superpower, can be proud of its role as a champion of freedom, as a bulwark first against Fascism and then Communist Imperialism through five decades. It now is given the historic opportunity to become a champion of the planetary ecosystem to organize and lead an **international environmental defense initiative** in a well coordinated approach together with all free nations; but also, including the Soviet Union and its former Eastern European allies.

Although the realization of the proposed changes from military to environmental planetary defense will be exorbitantly costly and will also require enormous investments from private industry, all levels of federal and state government as well as from non-profit research and educational institutions, for a long time to come; the long-term future benefits truly justify the costs we will incur to make full use of this golden opportunity to redirect our national goals toward a sane environmental planetary defense policy. The benefits will be truly enormous in that with re-tooling our industry we, at the same time, will stop the costly production of obsolete products; it will create new long-lasting job incentives, require the generation of new vocational skills, new inter-disciplinary professions, and above all increase growth and profit opportunities for our badly ailing industries. Thus, by promoting our proposal on the change **'From Military to Planetary Environmental Defense'**, we are confident of offering strong new incentives which will also culminate in a new scholastic wave among our children and students at all levels similar to what was experienced world-wide after the sputnik-crisis and its charismatic resolution by late President John F. Kennedy. In fact, this concept of Environmental Planetary Defense should provide renewed national stimulus similar to that which placed man on the moon, but this time dealing with a truly realistic down-to-earth calamity, desperately requiring an immediate solution by instilling a more scholastic approach, so that we may be assured that all men and creatures can sustain a sane life on an environmentally healthy earth in the future.

This, of course, can only be achieved if the current explosive trend of global population growth can be reversed. But as population growth and environmental deterioration go hand-in-hand, a strong grip on this most crucial problem of controlled global population growth can only be achieved by strengthening environmental planetary defense. Our proposal of instituting an **'International Environmental and Economic Peace Corps of Professionals'** is also intended to deal with these related problems of combating poverty in the Third World and in the devastated regions of the former USSR with drastically reduced population carrying capacity. Thus, the question of controlling global population growth cannot be separated from planetary environmental defense. Conversely, without the truly developed nations, and the US in particular as the one remaining superpower, assuming the leadership in promoting and advancing planetary environmental defense, our drive for inducing global population control among Third World countries is in vain, because we then would lack the basic credibility for achieving this important goal. We must face up to the fact that environmental degradation, human poverty and over-population are part of a cycle. In the end all ecosystems have finite long-term population carrying capacities. There are fundamental limits on how

many humans a given ecosystem can support that, however advanced the technology, cannot be superceded. When human populations exceed these limits mass death through epidemics or wars or famine or mass emigration is inevitable sooner or later. Many places in the Third World, such as Bangladesh have already exceeded these limits, and Mexico and Brazil as well as other parts of Latin America are rapidly approaching their population carrying capacities. When these limits are reached, particularly in Mexico, the US cannot remain immune from the grave consequences. If the US is to assume the lead in a planetary environmental defense initiative it cannot remain passive or negative regarding efforts to not merely limit, but stop population growth. If it does, we will invite mass emigrations, especially from the Third World, genocidal warfare and environmental devastation followed by global ecological collapse before the end of the next century. Thus, it can be directly concluded that without accepting a shift from military to planetary environmental defense, we will only perpetuate the current trend of an explosive global population growth and, in turn, the extinction of many living species of our flora and fauna, the sprawl of poverty and misery on a global scale.

In conclusion, the US military and industrial defense establishment has unique capabilities and possesses ideal facilities worldwide that can be redirected to the urgent task of repairing and protecting the global ecosystem. By refocusing the freed excess capacity, the entire military defense industry will be able to play a major role together with our domestic and overseas bases, becoming pivotal assets in realizing these important goals for the true benefits of the survival of mankind - a high and noble task - for which it is ideally suited. Undoubtedly, a determined bold move from military toward planetary environmental defense would raise US political stock and provide a healing influence throughout the world, and thus reestablish credibility and trust in the US Constitution, morales and ethics we stand and fight for, and which thus could be made a part of our common terrestrial heritage on a global scale. Thus, let us graduate from environmental exploitation to environmental defense as our guiding principle when ushering in the twenty-first century.

6. ACKNOWLEDGEMENTS

This concept of **'environmental planetary defense'**, was developed through the author's life-history and his engagement on various International Joint Commissions (**US-CANADA:** Great Lakes Science Advisory Board; **US-USSR:** Baikal International Center for Ecologic Research; **US-JAPAN:** Kansai Science and Environmental Technological Megalopolis) and scientific bodies dealing with electromagnetic remote sensing and deep earth sounding of the terrestrial and planetary atmospheres and crusts. In tnis ongoing strive for global environmental defense, generous contributions of numerous colleagues, friends and co-strugglers, who shared our concerns, are gratefully acknowledged. Also, the continual encouragement of his colleagues at UIC; and, in particular, of Profs. Boyd R. Keenan, G.E. Otto Widera, Phillip L. Hawley, Dr. Wesley B. Leach, Vernon A. Miller and of Chuck Sklavanitis is sincerely recalled.

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TION, RESEARCH, POLICY & ARTS IN A MARITIME CONSERVATION AND LAKEFRONT RECREATION PARK: THE FORT SHERIDAN GREAT LAKES CENTER in coordination with establishing all wet-bed environmental laboratories within the nearby WAUKEGAN HARBOR site, of Lake County, Illinois, with the objective to: REQUEST FROM THE FEDERAL GOVERNMENT THE RECOMMISSIONING BY DONATION OF THE ENTIRE FACILITY FOR SAID PURPOSE WITH SHARED STATE, FEDERAL & INTERNATIONAL SUPPORT FOR CONTINUING FUTURE OPERATION AND FACILITIES MAINTENANCE.

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8. BIOGRAPHIES

Dr. Wolfgang-Martin Boerner is a Professor of the University of Illinois at Chicago, Department of Electrical Engineering and Computer Science and the Director of its Communications and Sensing Laboratory, engaged in acoustic, electromagnetic and seismic remote sensing and deep earth sounding research with applications to wide area remote sensing of the terrestrial and planetary atmospheres and sounding into its crusts. He was born in Papua New Guinea, spent his early youth in Oceanic and Austral Asia, before receiving his grammar school education at the August von Platen Gymnasium in Ansbach, West Germany, holding the degrees of Dipl-Ing. in Electromagnetic Communications & Sensing (Technical University Munich: 1963) and of Ph.D. in Electromagnetic Sciences (University of Pennsylvania: 1967, to which he transferred as a Fulbright exchange student). He then transferred to the University of Michigan, EECS, Radiation Laboratory, Ann Arbor, MI, where he was engaged in electromagnetic inverse scattering studies. He was with the University of Manitoba, EE, Winnipeg, Canada from 1968 to 1978, concerned with inverse problems in aeronomic sensing and imaging, before accepting a position at the University of Illinois at Chicago, as Professor and Director of the Communications and Sensing Laboratory within EECS. Dr. Boerner is a Fellow of IEEE, and a recipient of the Alexander von Humboldt & the Japan Society for Promotion of Science, US Senior Scientist Awards, respectively, and of the University of Illinois Senior Scholar Award.

Dr. James B. Cole is now a research physicist at the Naval Research Laboratory, where his research work embraces signal processing, pattern recognition, and lattice gas computational physics. He holds the Ph.D. in Physics (University of Maryland: 1987), the M.Sc. degree in electrical engineering sciences (University of Illinois-Chicago: 1981), the B.Sc. degree in applied mathematics and engineering physics (Illinois Institute of Technology, Chicago: 1972), and after completing his doctorate degree, he joined the NASA Goddard Space Flight Center as a National Research Council postdoctoral fellow, where he carried out both theoretical and experimental studies on cosmic rays. It was the problem of detecting and analyzing weak optical signals in cosmic ray detectors that led him to his present work. He also spent one year each in Germany at the University of Hamburg on a German National Science Foundation fellowship to work on magnetic phase transitions, and at the NTT Basic Research Laboratory, Musashino-Tokyo, Japan engaged in Human & Computer Image Analysis and Pattern Recognition. James B. Cole acquired a very broad scholastic and scientific background education resulting in an extraordinarily wide scope of interests; he served two consecutive terms with the US Peace Corps in West Africa (Ghana) traveling all over Africa; and then via Arabia, India, Indonesia, Indochina to Japan, where he added another two years of scholastic studies of his own. It was during these years of extensive scholastic world travel that made him an advocate for a future change from military to planetary environmental defense. He is multi-lingual, and fluently speaks, reads and writes Japanese, German, French and Spanish.

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